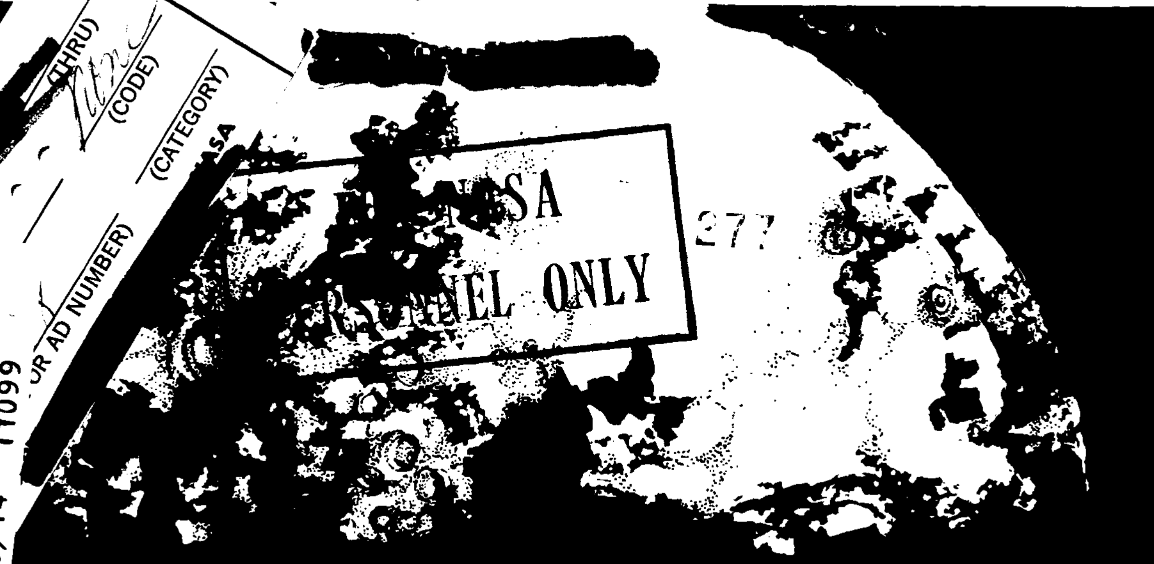


IONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT APOLLO

QUARTERLY STATUS REPORT (U)

NO. 9

FOR PERIOD ENDING
SEPTEMBER 30, 1964

MANNED SPACECRAFT CENTER

[redacted]

C69-1698

[redacted]

~~C65-2769~~

TABLE OF CONTENTS

[redacted]

Section | Page

LIST OF TABLES

LIST OF FIGURES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROGRAM

QUARTERLY STATUS REPORT NO. 9 (U)

for

PERIOD ENDING SEPTEMBER 30, 1964

By Manned Spacecraft Center

SUMMARY

Major accomplishments of the Apollo Spacecraft Program during this reporting period were the following:

1. Five CSM stabilization and control subsystems (SCS) were delivered to North American Aviation (NAA) for use in mission simulators 1 and 2 and for engineering evaluation. The definition phase of the Block II SCS has been completed, and NAA and Honeywell have been directed to proceed with the design.

2. Testing of the Apollo docking system was defined by MSC and includes three dimensional dynamic testing of the actual docking system in a thermal-vacuum environment.

3. Incorporation of a unitized couch design was directed by MSC. The new design results in a significant weight savings. The design will be used on all manned spacecraft starting with Airframe 012.

4. A decision was made to use a collective survival kit on all Block II spacecraft. The new kit, designed to support three astronauts, results in a weight savings of 12 pounds over individual kits.

[redacted]

5. The first CSM production environmental control subsystem (ECS) was installed in BP-14. Contamination checks, servicing and checkout are now in progress.

6. A complete cryogenic storage system for the AFRM 006 electrical power subsystem was delivered to NAA.

7. All ground support equipment required to operate the service propulsion subsystem was delivered and installed at the WSMR PSDF test stand no. 1.

8. The Rocketdyne engine throat insert cracking problem in the CM reaction control subsystem (RCS) was solved by the use of a special backing material in the insert. The material acts as a pad for additional support of the insert.

9. The launch escape subsystem qualification test program was successfully completed. The canard thruster development test program was also satisfactorily completed. Cartridges were ordered for minimum airworthiness tests of the deployment system.

10. All CSM pulse code modulation and up-data link engineering modules, except one, passed acceptance testing, and all engineering model VHF beacons were delivered to Collins Radio Company.

11. The present CM video camera will be limited to Block I spacecraft. Block II spacecraft will carry the camera being developed for the LEM and for lunar surface operations.

12. The Manned Space Flight Experiments Board proposed 13 experiments for SA 204: nine medical and four scientific.

a. Evaluation of the shape and location of the lunar surface sample containers is complete. The weight allocation for the containers is 80 pounds.

13. Fabrication of the LEM M-5 metal mock-up was completed. The mock-up is scheduled for an October review.

14. The test program to establish the degree of restraint required by the crew during lunar landing has completed the initial phases.

15. The LEM ECS feasibility tests were completed, and manufacturing is in progress on the design verification test components. Design verification tests are scheduled next quarter.

16. The LEM ac power distribution system was approved by MSC. The system consists of two 270-watt inverters redundantly feeding one AC bus.

17. Grumman Aircraft Engineering Corporation completed slosh test rig operation on the LEM descent propulsion subsystem. Final acceptance will depend on the evaluation of the test results.

18. The LEM ascent engine development program was completed at Arnold Engineering and Development Center. Tests this quarter consisted of a series of performance verification tests, a series of phase "C" thrust chamber evaluation tests, and a series of fire-in-the-hole tests.

19. The Apollo space suit assembly was redesignated as the extra-vehicular mobility unit (EMU).

a. Gemini suits will be used in the Block I Apollo flights to reduce the number of training suits originally scheduled for the Apollo flights.

20. The CSM ECS radiator will be redesigned to incorporate the fluid stagnation concept to allow a wider heat load variation.

21. The Block II CM G&N subsystem displays and controls were re-designed, and large increase in operational flexibility has resulted.

22. NAA acceptance check-out equipment (ACE-SC) Station No. 1 successfully completed acceptance testing and was declared operational.

23. The Apollo "black-box" sparing policy was implemented for all Apollo contractors. The policy states that electrical and electronic flight hardware will be spared to the black-box level.

24. Fabrication of the CM, SM, and launch escape subsystem for BP-27 was completed. The CSM will be shipped to MSC in October for structural testing.

25. Installation of systems tubing and wiring harnesses on BP-14 was completed, and the vehicle was transferred to S&ID Apollo Test Operations. The electrical power and environmental control subsystems were also installed, and subsystem testing is in progress.

26. The structural details of AFRM 006 were completed and structural subassembly is in progress.

27. Boilerplate 28 was assembled and delivered to NAA Engineering Development Laboratory. The first test drop is planned for late October.

28. Boilerplate 23 (BP-23) checkout was completed at Downey in September and the BP-23 was shipped to WSMR. It will be launched in October by a Little Joe II for a maximum dynamic pressure abort.

29. Apollo spacecraft mission A-102 (BP-15) was successfully accomplished at Cape Kennedy on September 18, 1964. The mission satisfactorily demonstrated the alternate mode of tower jettison using the launch escape and pitch control motors. Complete evaluation is in progress, and test results will be published next quarter.

PROGRAM DESCRIPTION

The Apollo Space Vehicle, consisting of the spacecraft and launch vehicle, is depicted in figure 1. The spacecraft is the responsibility of the Manned Spacecraft Center (MSC), Houston, Texas, while the launch vehicle is being developed by the George C. Marshall Space Flight Center (MSFC). The Apollo spacecraft configuration is shown in figure 2.

The Apollo spacecraft is composed of three separable modules: (1) the Command Module (CM) which houses the crew from the earth to the vicinity of the moon and during their return to the earth, (2) the Service Module (SM) which contains the propulsion subsystem as well as other subsystems, and (3) the Lunar Excursion Module (LEM) which separates from the Command and Service Modules when in lunar orbit, descends to the lunar surface for manned exploration, and returns the crew to the orbiting CSM.

The basic launch vehicle for lunar missions is the Saturn V, which consists of three stages: the S-IC, S-II, and S-IVB. The S-IC utilizes LOX-RP-1 propellants for five F-1 engines while the S-II stage used LOX-LH_2 propellants for five J-2 engines. LOX-LH_2 propellants are used for the one J-2 engine in the S-IVB stage.

NASA-S-64-1713

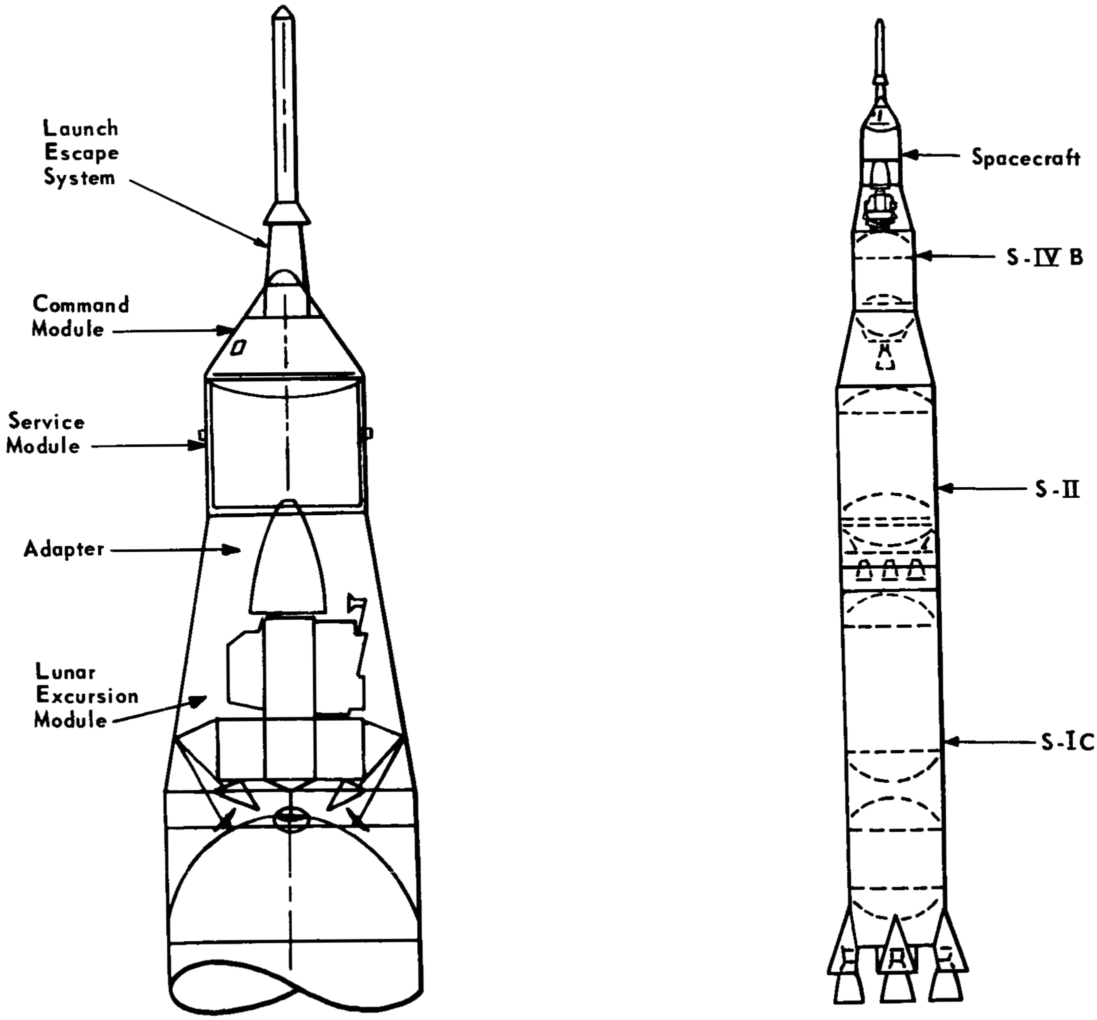


Figure 1.- Apollo space vehicle configuration.

NASA-S-64-1714

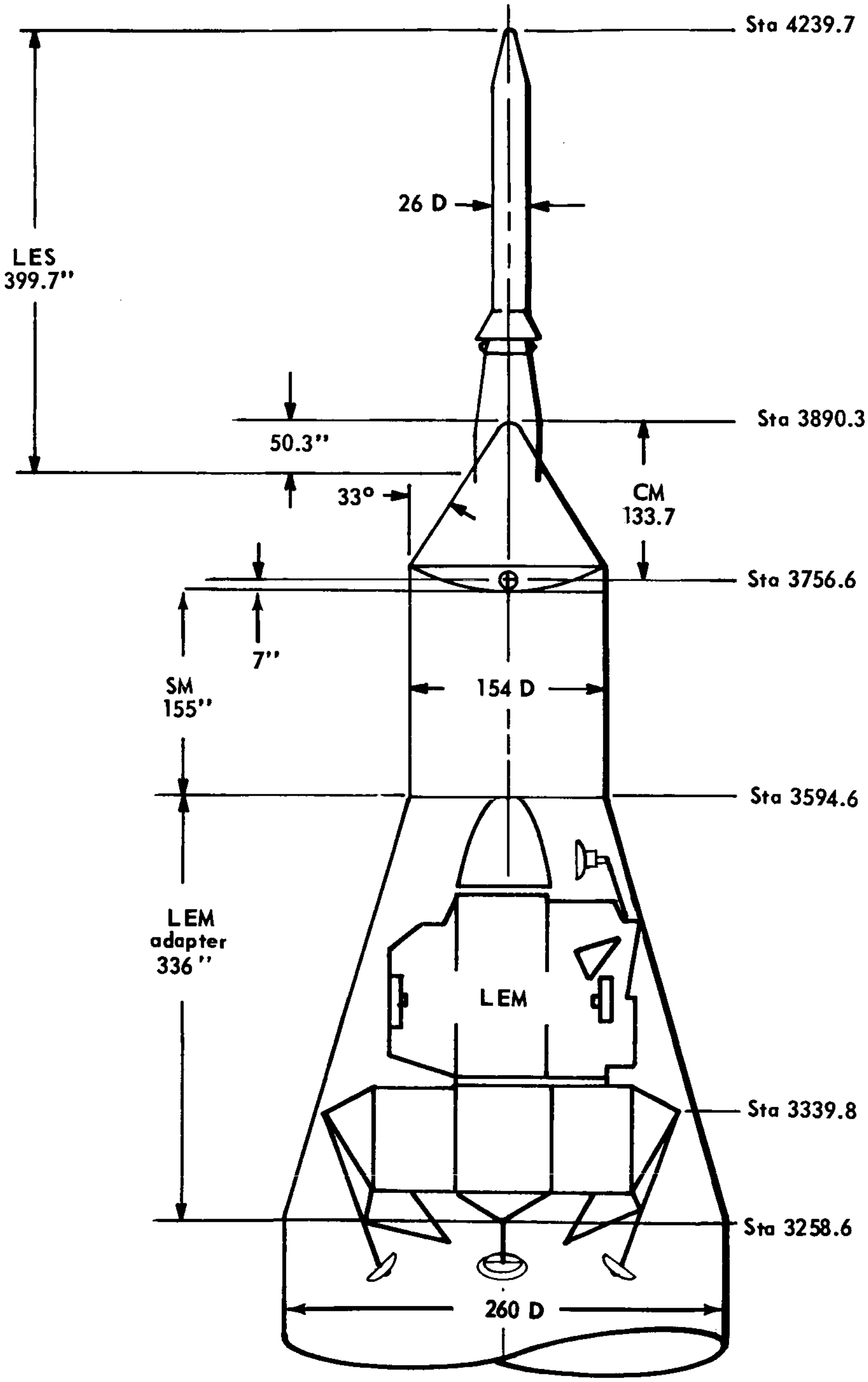


Figure 2.- Apollo spacecraft configuration.

SPACECRAFT SUBSYSTEMS DEVELOPMENT

COMMAND AND SERVICE MODULES

Guidance and Navigation Subsystem (G&N)

The final definition meeting for the Block II G&N subsystem was held at MSC on August 18, 1964. The results of the Block II definition phase are being published as a data book. Preliminary issues were distributed for review on September 17, 1964. Upon receipt of comments and revision, the data book will be given formal distribution. Preparation of the CEI-Part I specification is expected to be released in November 1964.

The computer for G&N System AGE-6 was shipped to AC Spark Plug, and system testing was accomplished. Shipment of AGE-6 to the MIT Lab at NAA is expected by October 15, 1964.

The requirements for the hermetic sealing of the G&N subsystem within the CM have indicated design problems may result. Design changes necessary to satisfy these requirements are under investigation.

Stabilization and Control Subsystem (SCS)

Stabilization and control subsystems were received by NAA for mission simulators 1 and 2, evaluator 2, an engineering simulator, and development engineering.

The SCS for verification tests (Phase III) was installed on the 13-foot air-bearing table at Honeywell, and dynamic closed-loop testing is in progress.

Block I SCS for spacecraft 012 and subsequent vehicles will incorporate a manual rate-command capability for control of the SPS thrust vector control loop.

The program definition phase of the Block II SCS has been completed, and direction to proceed has been given NAA and Honeywell for the design phase.

Structural Subsystem

The BP-15 flight data have been reviewed. Maximum fluctuating pressures of 166 db (overall rms value) were measured on the SM in the vicinity of the RCS. SM-RCS nozzle vibrations, with amplitudes exceeding the design values, were recorded. The vibration records give no indication of a structural failure of the RCS. The CM X-axis accelerations showed a 10 cps oscillation, with a peak-to-peak value of about 1.8g during holddown. Further analysis is required to determine the significance of the oscillation, which damped out rapidly at lift-off. The maximum flight loads experienced by BP-15 were low ($\alpha q < 1000^\circ$ psf).

An SM oxidizer tank has been tested as required by a vibration test, followed by a 28-day creep test, and finally a "burst" test. Rupture occurred on the final test at a pressure of 124 percent of the ultimate design pressure.

An 18-month contract was signed in August with the Avco Corporation for an investigation of simulated meteoroid damage to ablative heat shield materials.

The Bell Aerosystems Company has been awarded a contract to perform a structural analysis of the CM aft heat shield when subjected to translunar or reentry environments. Five thermal and/or mechanical loading cases are to be analyzed and one or more water impact loadings will be considered by the first of April 1965.

A contract has been let to the Utah Research and Development Company for testing the effectiveness of aluminum honeycomb shields in preventing meteoroid damage to liquid-filled spacecraft tanks. This two-month program is to be completed December 1, 1964.

Mechanical Subsystems

A concept for testing the Apollo docking system was adopted by MSC on September 25, 1964. The concept, originated by MSC, involves three dimensional dynamic testing of the actual docking system in a thermal-vacuum environment. See figure 3.

NASA-S-64-1711

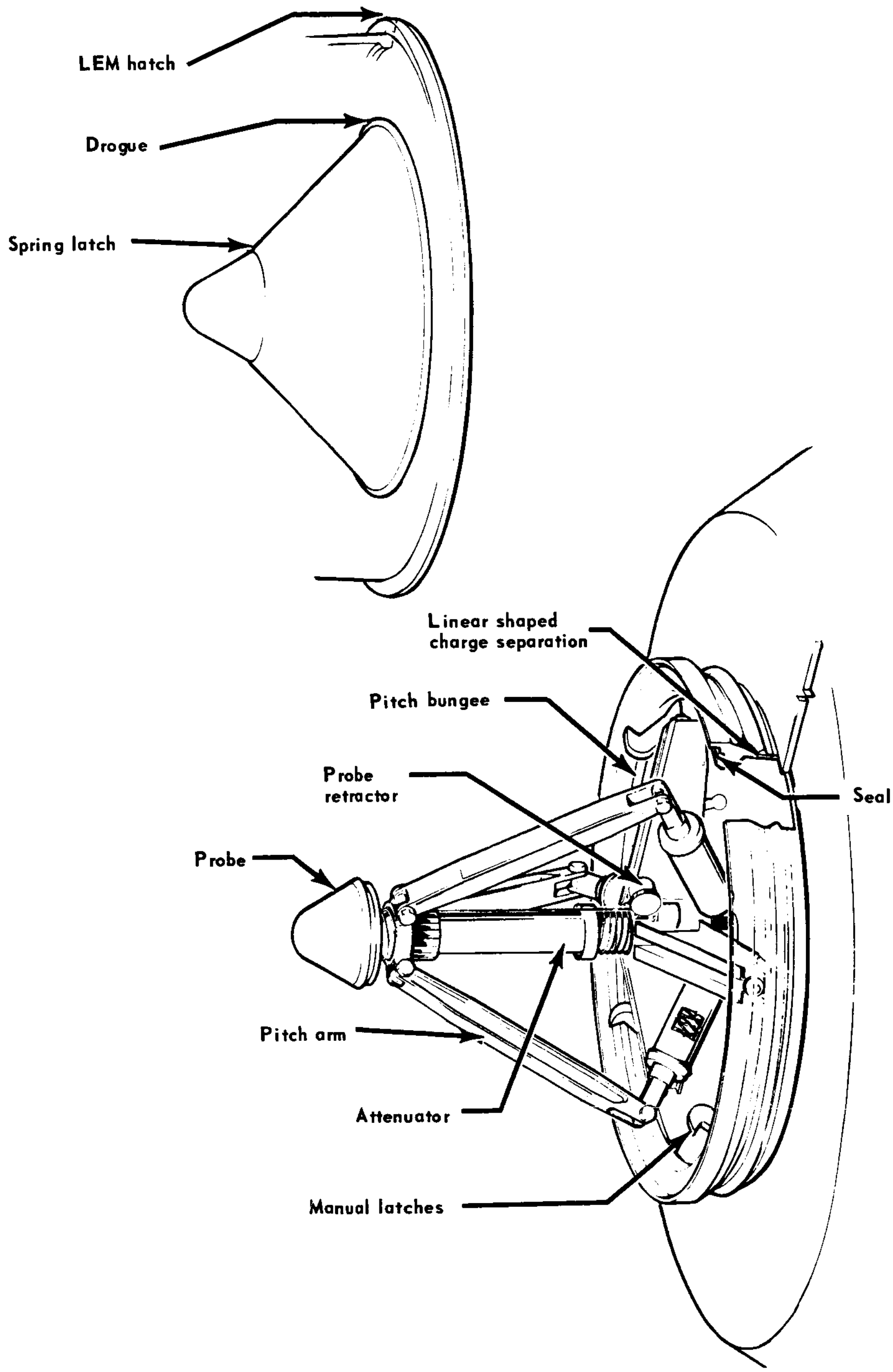


Figure 3.- Probe and drogue concept.

The Apollo flotation system uses three inflatable bags, which are positioned around the crew transfer tunnel on the parachute deck. The system is used to erect the CM if it should assume an inverted position. System requirements and configuration have been established.

The unitized couch design, use of which was made possible by the elimination of requirements for a removable center couch, was authorized by MSC in September 1964. The unitized design will permit significant weight savings and will be incorporated on all manned spacecraft starting with AFRM 012. The present Block I couch, with modified lower leg restraints, will be employed as an interim measure on AFRM's 006, 007, 008, and BP-28.

The Apollo ingress/egress hatches and the astro-sextant door are being manufactured on schedule.

The launch escape tower canard system, which is pyrotechnically actuated, is used to reorient the CM from an apex forward position to permit parachute deployment during launch aborts. The first flight item canard assembly was shipped September 25, 1964, to White Sands Missile Range for installation on BP-23.

Thermal Protection Subsystem

At the Block II mock-up review held at NAA on September 30, 1964, major changes in the design of the thermal protection subsystem (TPS) were proposed.

The CSM umbilical will be redesigned and relocated on the +Z-axis to eliminate the umbilical protuberance and to increase the L/D. At CSM separation, the umbilical is severed by redundant shaped charges at the CSM umbilical interfaces. The design will also include protection from micrometeoroid impact. An access door on either side of the umbilical has been added for servicing.

Four penetrations were added to the forward heat shield for the S-band antennas.

The Block I type shear compression pads on the aft heat shield have been eliminated and replaced by flush pads to transmit the loads through a depression around the pad.

A temperature control coating with favorable solar absorptivity and emissivity characteristics has been added to the CM, and it will limit the maximum equilibrium temperature of the ablator when facing the sun to approximately 100° F at any time prior to entry. The coating will be protected during launch by the boost protective cover.

The scimitar antennas on the CM in Block I vehicles will be mounted on the SM in Block II vehicles, and the hatch window has been deleted.

It is planned to qualify the Block II ablator on the Block I airframes 017 and 020. These spacecraft will be configured with a Block II nonfunctioning umbilical to assess the heat penetration to the inner structure.

On August 7, 1964, the first Apollo CM stainless steel substructure for airframe 006 was delivered on schedule to Avco for manufacture of the ablator. The complete heat shield is scheduled for delivery to NAA in January 1965.

All the stainless steel substructure panels for airframe 008 and 90 percent of the panels for airframe 011 have been received from Aeronca by NAA.

On August 18, 1964, the R-4, 5-stage Scout, with a nose cap of the Apollo material (Avcoat 5026-39), was flight tested. The vehicle reentered at a velocity of 29 000 ft/sec. Data on the performance of the material were obtained up to 14 seconds after peak heating rate, at which time all the ablator had been removed. Flight test results and their impact on the Apollo design are being analyzed.

Earth Landing Subsystem

A large number of one-quarter scale CM model impact tests were conducted at Langley Research Center. The model has an elastically scaled heat shield with the bending stiffness of prototype spacecraft. The model was instrumented to obtain pressure and acceleration data along with heat shield deflection data. These tests have been useful in defining the water impact pressures expected with various weights, velocities, and attitudes. In addition, the data are being evaluated to determine drop test conditions for BP-28 (the structural impact test article). The first test of BP-28 is scheduled for October 28, 1964.

Crew Equipment Subsystem

A materials selection program has been initiated by MSC which will minimize the individual efforts of the contractors. Much similarity should exist between materials employed in the CM and LEM cabins, Gemini, and Mercury; therefore, a mutual effort among contractors to accelerate the establishing of an acceptable materials list is underway.

Block II vehicles will employ a collective 3-man survival kit. A 3-man life raft, replacing three 1-man rafts, plus the resultant sharing of many kit components yields a first tier weight saving of about 12 pounds.

Personal hygiene equipment has been converted to government furnished equipment (GFE) as a result of the exploitation of the Gemini development and procurement programs.

The specification for bioinstrumentation has been completed. The document reflects the requirement for both major ground test and flight hardware. Procurement action has also been initiated.

Zero-g testing on the KC-135 aircraft at Wright-Patterson AFB has provided a preliminary demonstration of the acceptability of the couch/restraint, G&N station arrangement, and crew transfer from CM to LEM utilizing umbilicals. The latter included removal of the docking mechanism from the tunnel.

A study to integrate a restraint system into suit design has been completed. The summary conclusion was that the imposition on suit design would be significant, and it showed no advantages. Further considerations of this approach are dismissed.

Environmental Control Subsystem

The first production environmental control subsystem (ECS) was installed in Boilerplate 14. Pressurization tests on the CM water-glycol system began on September 18, 1964. Leakage occurred at numerous joints and B-nut connectors in the system. The leaks were corrected. The command and service module ECS contamination checks, servicing, and checkout are now in progress.

Group I ECS qualification testing for Block I has been completed satisfactorily on 12 components, and ten others are in progress. Burst testing of components has been delayed until all other uses of the component have been completed.

The second production configuration ECS to be used for the breadboard test program was delivered to NAA in September. The test vessel is still being modified to accept the ECS installation and other crew equipment for the manned ECS development tests. System buildup for the waste-management system development test program is in process, and testing should start before November 1.

Design of the postlanding ventilation system has been implemented for Block I and Block II. Both utilize the same configuration except for the location of the inlet and outlet valves. The design consists of a two-speed fan (150 cfm for day and 100 cfm for night) and a flexible inlet duct which is erected after landing.

Radiator testing at Ling-Temco-Vought is scheduled for November 9 through November 16. The test program is in a deep space analysis, and will include approximately 80 hours of space environment simulation emphasizing performance characteristics as affected by transients and edge effects.

Electrical Power Subsystem

Power Distribution.- A review of the design criteria, circuit schematics, earth landing system sequencer relocation, and delivery schedules of the operational mission event sequence controller (MESC) was held on August 20, 1964. Major results follow:

a. The earth landing sequence controller (ELSC) will be relocated in the scientific equipment bay to provide accessibility for checkout.

b. Autonetics will start qualification tests on MESC and service module jettison controller (SMJC) on February 15, 1965, with both to be completed August 15, 1965.

c. Northrop will start qualification tests on ELSC on December 10, 1964, to be completed February 1, 1965.

d. NAA will start qualification tests on CM reaction control system controller (RCSC) on December 1, 1964, to be completed January 10, 1965.

Eagle Picher Company started qualification testing August 3 on six of the 25-ampere-hour entry batteries. The testing will be completed October 6, 1964. Test results have all been satisfactory as of September 30 with the exception of one unit which failed insulation resistance tests after the humidity test. Eagle Picher is currently investigating the cause of the failure.

Electrical Storage Battery Company has completed development of the pyrotechnic batteries and has begun to manufacture production units.

International Telephone and Telegraph Corporation is to begin qualification testing on the battery charger by October 15, 1964.

The electrical power subsystem breadboard test began July 28, 1964, and will be completed in December 1964. The BP-14 electrical power distribution system verification test was completed on September 28, 1964, except for the a-c sensing unit which will be tested October 8, 1964. Test results are satisfactory.

Fuel Cells.- The main effort in fuel cell development during this quarter has been to incorporate design improvements into test hardware for evaluation. The major changes include individual cell redesign to reduce corrosion problems, lowering module operating temperature by 35° F, reducing condensor exit temperature from 190° F to 160° F, and providing reactant pressure control during startup.

Three significant endurance tests took place during this period. Power plants X398-12, X405-10, and X406-6 were built using all the latest improvements. The results of these tests as of September 30, 1964, are shown in the following table:

Module	X398-12	X405-10	X406-6
Time at temperature, hrs	433	733	480
Time on load, hrs	279	611	424
Time on Apollo Mission Profile, hrs	245	586	400
Number of starts	8	7	3
Remarks	Test continuing	Glycol pump replaced after 501 hours on load. Module completed 150 percent vibration tests in 3 major axes. Now in teardown	Module shut down after completing test

A recent cost reduction program has resulted in a realinement of the qualification test program into two parts. In part one, two modules will be tested to support Block I unmanned flights. These tests will start in December 1964 and continue to February 1965. In part two, tests on two additional modules, which will include off-limits testing to support manned flights, are scheduled.

NAA is continuing with fuel cell tests in the Engineering Development Laboratory. They have run single- and two-module tests at sea level and single-module vacuum tests in the modified test facility. Two- and three-module operations in a vacuum are scheduled to begin shortly. Test schedules have been extended because of the cost reduction program.

Cryogenic Storage.- The second and third Inconel O_2 pressure vessel qualifications burst tests were successfully completed. Vessel four will complete this program. Additional tests conducted at Lewis Research Center on the titanium material indicated that the metallurgical grain size is adequate.

A complete system for AFRM 006 and valve modules for BP-14, the breadboard, and AFRM 001 were delivered. The contamination problem with the valves appears to have been solved by the improvement of plating and cleaning procedures.

A number of fan-heater motor stators cracked during cold shock tests. The failures were caused by poor quality control on the stator shims. Although this problem appears to be resolved, late deliveries have caused delays in testing of engineering model tanks.

Service Propulsion Subsystem

All test stand number one ground support equipment required for the operation of the service propulsion subsystem was delivered and installed at the propulsion subsystem development facility.

A development type engine was attached to the F-2 fixture (heavyweight propellant supply system) and a functional check was performed. The first hot firing was conducted on September 22, 1964. A malfunction in the main propellant valve delayed ignition for approximately 9 seconds. A new valve was installed and the test was rerun on October 1, 1964. All objectives, with the exception of partial loss of instrumentation, were achieved. This series of tests will continue through January 1965. The primary objectives are to determine the effects of defined malfunctions on the overall system.

A similar system, designated the F-3 test fixture, was installed in the J-3 altitude test cell at the Arnold Engineering Development Center. Instrumentation installation and facility verification are in final phases pending an integrated functional check-out of the propulsion system and F-3 fixture. The first firing is scheduled for December. These tests (phase II) will continue through March 1965. The primary objectives are engine-hardware design evaluation and the determination of the effects of off-design conditions on engine operation and performance.

The development of a baffled injector is progressing satisfactorily. A total of 820 seconds of firing time has been accumulated with a

5-4-2 type drilled to a POUL-41-26 pattern. Data resulting from three 5-second firings in a stainless steel chamber indicated C^*'s of 97.28 percent, 97.49 percent and 97.19 percent of the theoretical amount.

Six bomb tests with 157-grain bombs were performed and all recovered within 10 milliseconds. A 778-second simulated-mission duty cycle was accomplished in an ablative chamber without causing severe streaking. The target-design freeze date for a qualification injector is December 1964.

The propellant-gaging system continues to be the pacing component under development. The start of design verification testing (DVT) has slipped to October 1964, resulting in qualification tests being rescheduled for completion in January 1965. The slippage is attributed to design modifications associated with the probe and propellant utilization-valve fabrication. In order to off-set any further delays, hardware of a qualification configuration is being installed in the first vehicles.

Reaction Control Subsystem

Command Module.- Primary effort has been concerned with the breadboard phase II system. This system, assembled with pre-qualification hardware, is being tested in the Engineering Development Laboratory at Downey. Excessive pressure transients have been recorded during pulse mode operation; also, several failures have been recorded in the Rocketdyne engine valves. These problems are being investigated.

The Rocketdyne engine throat-insert cracking problem has been solved by the use of a special "backing" material for the insert which acts as a pad to provide additional support.

Qualified tanks will not be delivered for AFRM 009; however, the tanks will be of the qualification configuration, and will be qualified prior to flight. The present configuration is the single-ply, oversized bladder in the command module (CM) and a single-ply, net size bladder with a liquid side vent for the service module (SM).

Service Module.- Primary effort has been concerned with the SM RCS engine. The optimization of the "pre-cup" design is complete and official direction has been provided for the incorporation of a fuel-valve standoff for passive thermal control. The problem of thermal control has not been entirely resolved. The engine design limit requires about 8 Btu/hr as constrasted to the previously stated requirement of 2 Btu/hr. The vehicle design must be compromised to provide the additional heat transfer capacity.

Static firing tests of the service module RCS breadboard system have indicated (as in the CM RCS breadboard) that hydraulic transients could cause problems with propellant utilization and/or operation of the "pre-cup" design in the engine injector. Verification of the system-engine interface may require additional altitude testing.

Launch Escape Subsystem

The Apollo mission A-102 (BP-15) was conducted September 19, 1964. A primary test objective was to demonstrate the secondary mode of tower jettison using the launch escape motor. The mission was successful.

A reduction in the scope of the LES qualification test program was accomplished, and the number of test motors was reduced from 28 to 20 for the launch escape and tower jettison motors and from 30 to 22 for the pitch control motor.

Launch Escape Motor.- The launch escape motor qualification test program was successfully completed on August 30, 1964, with the static test of the 19th and 20th motor.

Pitch Control Motor.- The pitch control motor qualification program was successfully completed on September 30, 1964, with the static test of the 21st motor. All 21 tests were conducted during the reporting period. The 22nd motor (motor III-2) was not statically tested because the motor failed to pass a "leak" check following a drop test. Because of the severity of the drop test, no specific requirement for static testing the motor had been established.

Tower Jettison Motor.- Four tower jettison motors (two development and two qualification) were successfully tested. A fifth motor, the 3rd-qualification test motor, experienced a malfunction in the spot welds on the motor-interstage connecting rings both fore and aft. The failure was attributed to the poor quality control of a Thiokol Chemical Corporation subcontractor. As a result of the failure, a quick fix was applied to the BP-15 tower jettison motor interstage structure, and a permanent fix was initiated for the remaining Block I interstage structures. The BP-15 fix consisted of strengthening the interstage connecting rings with $\frac{1}{4}$-inch-diameter high shear bolts. The permanent fix consisted of strengthening the same area with $\frac{3}{16}$-inch-diameter high shear rivets.

The interstage failure at Thiokol will result in an approximate 8-week down time of the test stand and a corresponding slippage in the completion of the qualification motor test program. Completion date is estimated to be in March 1965.

Pyrotechnics Subsystem

The Canard thruster development test program was satisfactorily completed. Cartridges have been ordered for minimum airworthiness test of the deployment system.

A space ordnance system shorting (SOS) plug has been designated as an acceptable substitute for the shorted electrical connector now required on all electrical initiators. Because of its low cost (approximately $1.00), the plug can be thrown away; thus eliminating return, handling, and reinspection costs necessary with the shorted connector. Further, the initiator can be torqued with the plug installed; this cannot be done with the connector.

NAA has been directed to purge all "shorting" springs from existing initiators as soon as shorting plugs can be obtained and to take immediate action to assure that no initiators or devices are shipped to launch sites (WSMR and AMR) without the SOS plug.

Twenty units of the Hi-Shear initiator successfully passed design verification tests (DVT). Both versions (SOS and Hi-Shear) of the Apollo standard initiator are ready for the qualification test program. Both vendors have guaranteed delivery of qualified configurations for fixed prices. Both qualification test programs are scheduled to be completed by early November.

A low order detonation during a recent acceptance test of detonators has resulted in changing the main charge design and consolidation pressure. The single pellet main charge, consolidated at 10 000 psi, has been changed to an ignition charge of 200 mg RDX consolidated at 1250 psi, and a main charge of equal weight was consolidated at 15 000 psi. Tests have proved the fix to be a satisfactory improvement.

Dual Mode Bolt (LE Tower Separation).- Ordnance Associated has submitted a new delivery schedule to NAA which will not support BP-23; therefore, the NAA decision to use single mode bolts will be approved.

Firing of the linear shaped charge (LSC) cartridge assembly failed to cut the plate section of the bolt. Investigation and corrective action is underway. Increased loading (150 gr/ft to 200 gr/ft) and a modified detonator LSC interface are being tested.

Single Mode Bolt.- A BP-15 bolt, which fractured after installation, was subjected to analysis at the Cape and NAA. NAA concluded that bending during installation caused cracking because of high heat treatment (R_c44) and cut threads. Complete failure was attributed to crack propagation under load. These conclusions agreed, in general, with those of the Cape laboratory.

Lot-7 bolts, having rolled rather than machined threads, were installed in BP-15 with care to eliminate bending loads during torque-down.

NAA has been directed to provide spherical washers for both ends of the bolt in all future flight vehicles.

Block I Drogue Disconnect.- During acceptance tests of linear shaped charge assemblies for the Block I dual drogue disconnect, the 50 gr/ft charge failed to sever the Inconel tension member.

A 100 gr/ft charge is adequate, but its use would result in a complete redesign of the entire fitting, and it also presents shrapnel problems. NAA will try specially produced 65, 75, and 85 grain charges to determine the minimum required and to assess the shrapnel problems.

Communications Subsystem

Pulse Code Modulation (PCM) Telemetry System.- All pulse code modulation (PCM) engineering models have been completed and have passed acceptance testing. Environmental testing of the development model mechanical mock-up has been satisfactorily completed.

Up-Data Link (UDL).- The first engineering models of up-data link (UDL) spacecraft equipment and bench maintenance equipment (BME) passed acceptance test and were delivered to NAA.

The central timing equipment (CTE) updating function of the UDL was authorized by NASA and will be incorporated for Block I on UDL development model-5.

A hard-copy independent display (teleprinter) has been authorized for use on the Block II spacecraft and will interface with UDL equipment. A procurement specification and request for proposals have been initiated by NAA and the proposals are expected early next quarter.

C-Band Transponder.- All engineering model transponders except E-5 have been delivered to Collins Radio Company (CRC). E-5 is to be completed in mid-October and then subjected to development model acceptance test requirements.

VHF Beacon.- The last engineering model beacon, E-4, has successfully completed acceptance testing and has been delivered to the CRC integration test group.

D-model design and testing are now in progress with the incorporation of improvements realized during engineering model production and testing.

Audio Center.- NAA was directed to implement an additional audio-center mode switch position for Block II spacecraft as requested by astronauts. This mode switch position will allow a hot interphone capability without RF transmission, and it will allow the selection of any desired communication link without excessive switching.

VHF and HF Equipment.- All engineering model equipment required for delivery has been shipped. BP-14 and the CRC subsystem integration test group were both supplied with the engineering model equipment.

Antennas.- The study contracts for high gain S-band antennas awarded to Hughes Aircraft Company, General Electric, and Dalmo-Victor are to be completed by November 1, 1964. Evaluation of these studies will result in the selection of a contractor to design and develop the antenna.

NAA has been requested to study the implementation of a second high-gain antenna on the CSM. This is considered to be highly desirable because of reliability considerations and attitude constraints imposed by requirements for navigation sightings, thermal control, and thrust vector corrections.

The Dorne and Margolin four-month study contract for development of flush mounted antennas for VHF, UHF, S-band, and C-band has been completed. Results of this study are being evaluated for possible application to Block II CSM.

Operational Instrumentation Subsystem

Transducers.- The final purchase order (a high-range calorimeter for the heat shield) for AFRM 009 instrumentation was released on September 21, 1964. It is estimated that seven months will be required by Republic Hi-Temp Instruments Corporation to complete delivery.

The Rosemount flowmeter redesign is complete and testing is underway. Redesign consisted of thermally insulating the sensing element from the electronics. The first use of this item is in AFRM 001. There is much confidence in the new design and the accompanying schedules.

Signal Conditioning Equipment (SCE).- The E-3 model of the SCE scheduled for installation in BP-14 was received on schedule at NAA on August 28. The design proof model, Model E-1 (not scheduled for vehicle installation), has successfully completed a majority of the required tests.

Data Storage Equipment (DSE).- DSE D-8 for BP-14 has been received at NAA. Model E-7 for AFRM 009 has successfully completed preliminary testing and is scheduled for formal acceptance test. Shipment to NAA is expected on October 15.

Central Timing Equipment (CTE).- CTE model E-2, for BP-14, and its associated bench maintenance equipment (CTBME) were received by NAA on August 24.

Instrumentation/Communication R and D Subsystem

During this period MSC has delivered government furnished equipment (GFE), development flight instrumentation (DFI) to NAA for BP-22. Effort is being continued to provide the following DFI systems:

Vehicle	Delivery Schedule to NAA
AFRM 002	December 1, 1964
AFRM 010	January 1, 1965
BP-23A	January 1, 1965 (late components 8-15-65)
AFRM 006*	December 1, 1964
AFRM 008*	February 15, 1965
AFRM 009*	December 12, 1965
AFRM 011*	March 15, 1965
BP-14*	February 15, 1965

*Requires communication hardware only.

The above programs are generally on schedule. Program support requirements for BP-23A cannot be fully specified until BP-23 has been launched and postflight evaluation of the reusability of flight hardware is accomplished.

Instrumentation/communication subsystem on BP-15, launched from Cape Kennedy, was successful.

Video Transmission Subsystem

Three engineering models were constructed and underwent development tests. All tests were passed with the exception of one part of the electromagnetic interference test. A design change is being made to correct this problem. D-models were fabricated up to the final assembly stage where they were held pending development test results. D-models will undergo qualification tests during the next period.

A decision was made to limit the use of the present CM camera to Block I spacecraft only. All Block II spacecraft will carry the camera which is being developed for the LEM and lunar surface operations. It is intended that this camera is to be used in the CM, then transferred to the LEM. After lunar operations are concluded, the camera will be transferred back to the CM.

Scientific Equipment

MSF experiments board has submitted to MSC the proposed experiments for SA204. The proposal includes four science experiments and nine medical experiments. Two of the science experiments (nuclear emulsion and astronomical observations with a U.V. camera) will require an airlock or quartz window. The other two (synoptic terrain photography and airglow horizon photography) can be accomplished with photographs taken through existing spacecraft windows.

By November 1964, MSC and NAA expect to determine the feasibility of incorporating most of the experiment package. NAA has undertaken a special study to determine the feasibility of a small airlock for the Block I command modules; the study will be complete by January 1965.

Recent analyses have shown the off-peak power availability for experiments on Block I flights to be 1000 watt peaks, 500 watt steady state, and 10 kw-hr.

The penalty to the scientific payload will be approximately 3.4 lbs of cooling water for each kilowatt hour. Block II power availability is expected to be the same.

Three tracks on the operational tape recorder have been requested for scientific experiments. Data transmission will be limited to tape playback on Block I flights. Direct telemetry of the data will usually be possible on Block II flights.

Standard wiring provisions for power and recording are being provided at three locations within the CM.

NAA, GAEC, and MSC have agreed on shapes for the lunar-surface sample return containers, which must be transferred from LEM to CM prior to transearth injection. There will be two 19- by 11.5- by 8-inch sample return containers. The weight allocated to the containers and contents is 80 lbs. They will be located in the center of the CM lower equipment bay. The weight and volume allocations for sample return containers will be used for other experiments on non-lunar landing flights.

In the LEM, the containers will be located on the -Y side of the aft equipment area under the upper docking tunnel.

LUNAR EXCURSION MODULE

Guidance and Navigation Subsystem

A series of LEM definition meetings began on September 1, 1964 to coordinate the design of the LEM guidance and control subsystems, and will continue bi-weekly for approximately eight weeks. All major decisions will be made in the program definition phase such that the LEM guidance and control subsystems will be completely defined and all interfaces resolved and signed off by January 1, 1965.

Stabilization and Control Subsystem

A LEM guidance and control definition study to integrate the subsystems was initiated with the contractors during this period. The definition study is scheduled for completion in early November. All interfaces are to be resolved by January 1, 1965.

The competition for procurement of the Abort Guidance Section (AGS) of the SCS resulted in the selection of STL as the Grumman subcontractor responsible for this equipment. A definition study is currently being conducted by STL to define tradeoffs of capability versus weight, complexity, et cetera. Information from this study will be used in the guidance and control definition study to decide on baseline AGS capability for design. The AGS provides a LEM abort capability only; it is not a backup guidance subsystem.

Structural Subsystem

The LEM structural subsystem is in the engineering phase. The metal mockup (M-5) has been completed and is scheduled for review October 7, 1964. Fabrication has been started on test vehicle model no. 2 (TM-2), LEM test article no. 2 (LTA-2), and test article no. 10 (LTA-10). Detail drawing release is in progress for LTA-3, the most important structural development test vehicle. See figure 4.

The LTA-2 and LTA-10 detail drawings are 96 percent complete and design stress analyses are about 90 percent complete.

The ascent-stage pressure-cabin riveted-joint sealant program has been completed except for the joint sealing demonstration. The feasibility, sealant screening, and sealant selection phases have been completed. Four sealants (Epon 919, RTV 601, DC-325, and RTV 1850) have been selected for use of the flight and test vehicles.

The major problem on the LEM structure subsystem is the docked stiffness and design loads between the LEM and the CM. A method of stiffness apportionment to NAA and GAEC is required to make each company responsible for its own structure and at the same time ensure that the first bending mode is compatible with the command/service module control system.

Landing Gear Subsystem

The landing gear is undergoing investigation in the laboratory with various component testing, which includes determining the natural frequency of the primary strut, bearing friction, and strain data for various loading conditions to verify design calculations. The bearing pressure design for the footpad has been verified, and the secondary struts are being prepared for testing.

A landing-dynamics parametric study was conducted by GAEC and MSC. This study included variations with surface friction, slopes, attitudes, attitude rates, planar and six-degree motions, and descent engine crushing. The results are being analyzed to determine the actual performance envelope for the LEM gear.

Crew Equipment Subsystem

The contractor-conducted test program to establish the degree of restraint required by the crew during the lunar landing phase progressed through the initial two phases. Load applications in the vertical and

NASA-S-64-6306

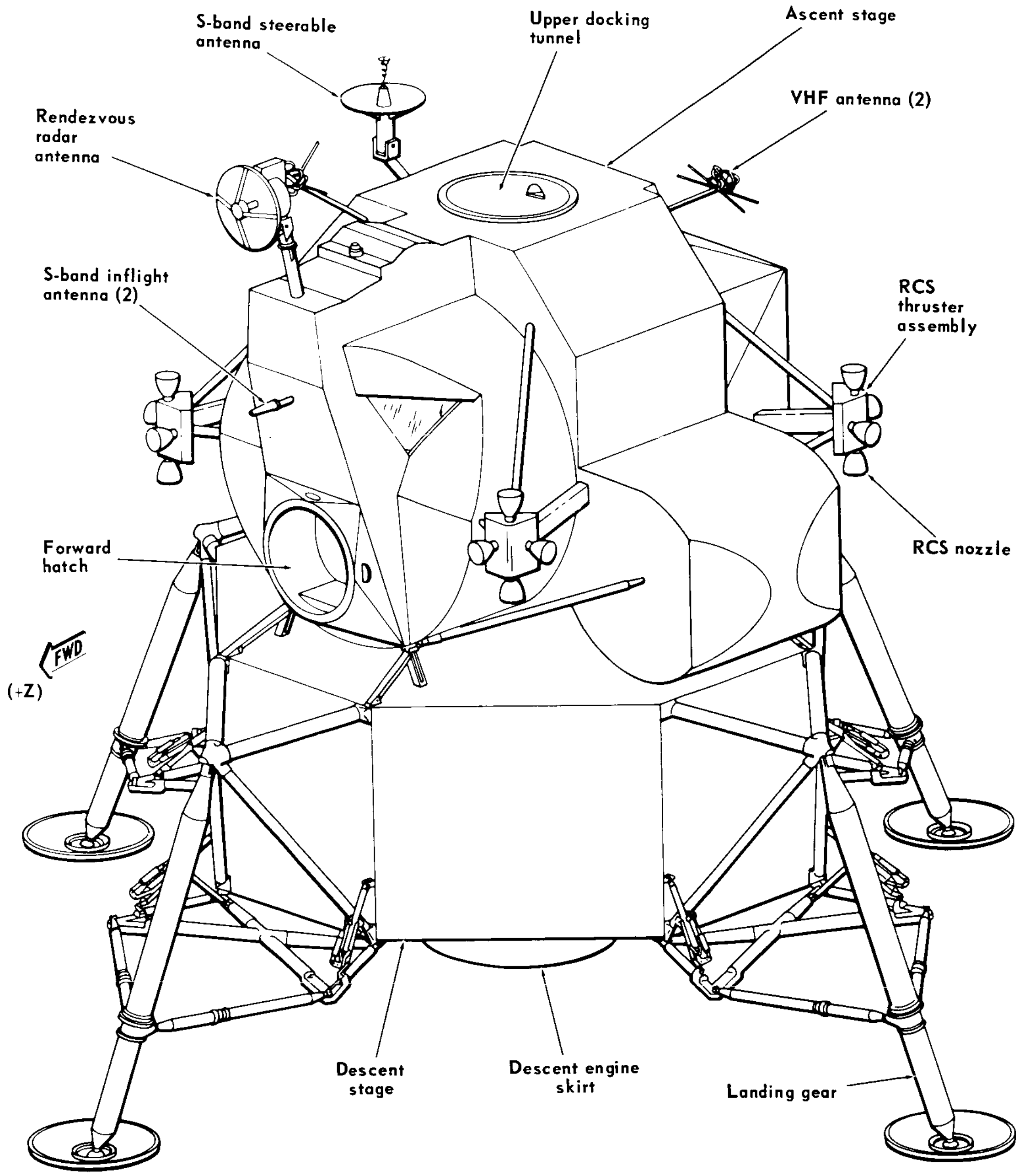


Figure 4. - LEM structure.

two horizontal directions revealed the crewman could withstand representative loads without benefit of restraint. The more critical condition is combined on-off axis loading. The program phase is to begin in early November.

Studies are being conducted with a suited subject on a simulated lunar terrain to establish the intensities, beam geometry, transport method, et cetera, for the portable light. The studies are not complete, but it appears the previously proposed helmet mounting is not acceptable because the advantages do not justify the imposition on helmet design.

Environmental Control Subsystem

The ECS design feasibility tests have been completed. Manufacturing is in progress on the design verification test components, and tests are scheduled to begin next quarter.

The suit circuit water evaporator has been changed from a plate fin type to a porous plate type similar to the coolant water evaporator. Early design efforts indicated that the porous plate type evaporator could not tolerate the inlet atmospheric temperature range expected. However, feasibility tests indicated that the porous plate can tolerate the inlet atmospheric temperatures, and that the plate fin type cannot provide sufficient cooling without excessive water carry-over.

Steady state thermal analysis shows that the cabin temperature may fall below 70° F during the lunar exploration phases of lunar night missions. Because this analysis is based on preliminary structural heat leaks and the lead time of a small electrical suit circuit heater to correct the situation is short, the decision to add a heater has been deferred.

Electrical Power Subsystem

Power Distribution.- In July, the a-c distribution system was approved by MSC. The configuration consists of two 270-watt inverters redundantly feeding one a-c bus. MSC has also approved the use of the a-c motor-inverter combination type of brushless d-c motors.

The d-c distribution system is being redesigned due to the new abort criteria established by MSC in August. Based on these criteria (abort on one fuel cell failure), GAEC has completed the determination of new auxiliary battery requirements. With the GAEC recommendation to operate equipment in the range of 20-32 volts, the battery requirements are 1800 watt-hours (45 lbs). However, to prevent the fuel cell output voltage from dropping below 27 volts, the battery requirements are 3120 watt-hours (78 lbs). GAEC recommends developing and using two 45 lb batteries for the second condition listed above. The data should be available for review by MSC by October 9, 1964.

Hamilton Standard Division was assigned the task of defining the recharging requirements for the portable life support system (PLSS) battery. It appears that a constant-voltage current limiting type of charger for recharging the PLSS battery is perferred. MSC is experimenting with a constant potential charge on silver-zinc batteries to determine adequacy of charge.

The line-voltage drop problem anticipated with the previous d-c distribution system concept is being lessened by the new abort criteria, the new battery requirements, and a new concept in the d-c distribution design. GAEC's re-evaluation of the problem is expected by October 12, 1964.

<u>Fuel Cells</u>.- New filling procedures have eliminated the short-time potassium hydroxide plugging problem, and runs of 400 hours are now being obtained. The long-term potassium carbonate plugging problem still exists although several solutions are under investigation.

The FCA is being redesigned to allow only a 50 Btu/hr heat rejection rate to the LEM vehicle with a maximum temperature of 220° F. A maximum reactant inlet temperature of 40° F and an average structure temperature of 160° F are assumed.

A 30-cell experimental fuel-cell model has been delivered to Grumman. Testing will begin about October 15, 1964.

<u>Cryogenic Storage</u>.- The preliminary cryogenic storage design review was held during the week of September 14, 1964, at AiResearch, and the results are now under study by MSC and Grumman.

Descent Propulsion Subsystem

Grumman has completed slosh test rig operations. Final acceptance will depend upon the evaluation of test results. The internal configuration in each of the propellant tanks used for anti-sloshing consists of aluminum riveted tabular baffles arranged into a longitudinal and lateral configuration, plus an anti-vortex device located at the propellant exit. See figure 5

NASA-S-64-6309

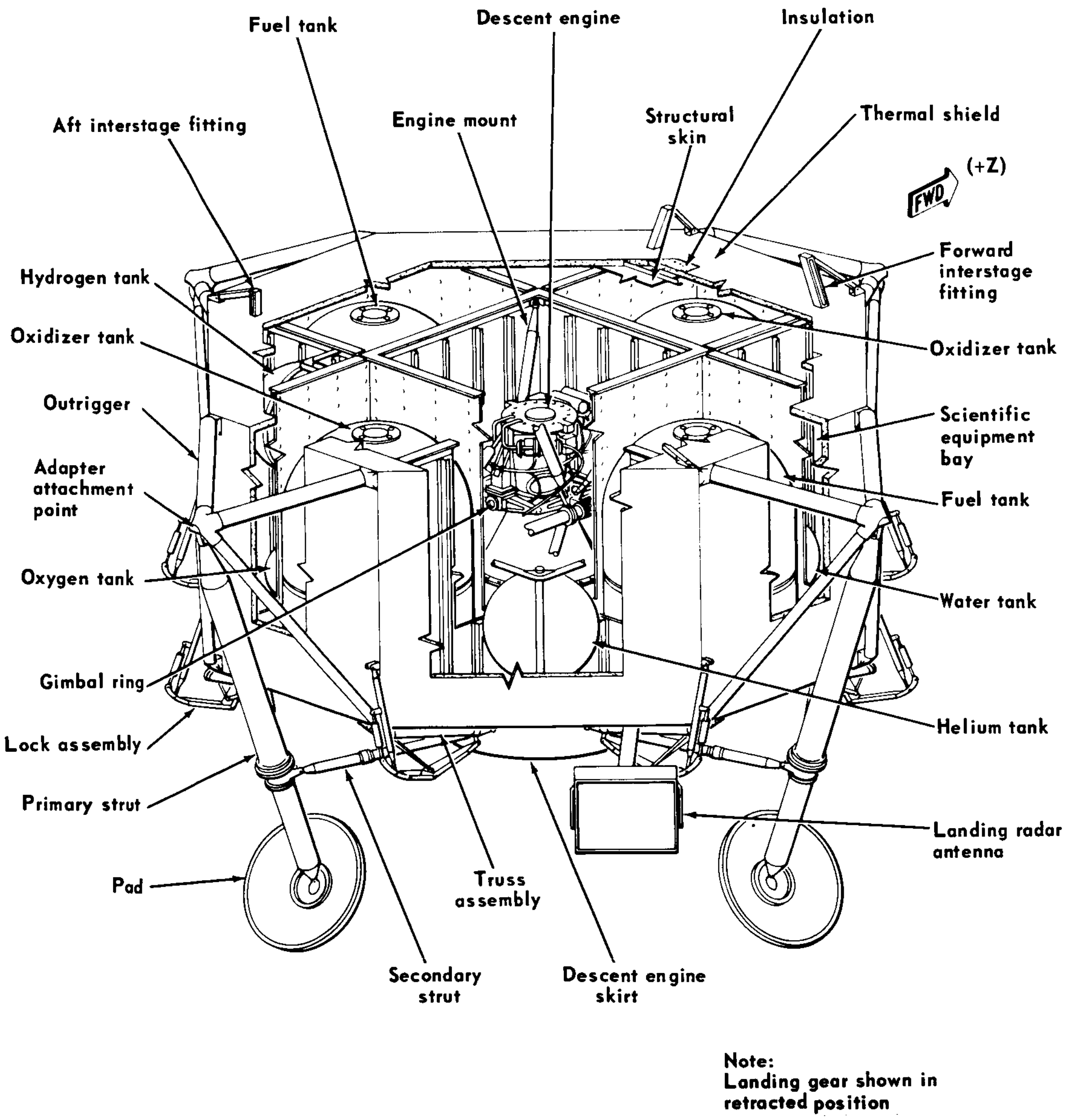


Figure 5. - LEM descent stage.

Heavyweight rigs HD-2 and HD-3 have been installed at the Rocketdyne and STL facilities, respectively. Rocketdyne has completed the checkout of the rig, and has performed a major milestone test which consisted of running the engine with a chamber pressure equal to the maximum tank pressure of 270 psia (relief valve setting) with full propellant tank volumes until propellant run-out occurred. The major objectives of the test were met. STL is in the process of facility and rig check-out.

The scheduled completion dates of the seven decision milestones have been set for November 15, 1964, for Rocketdyne and February 5, 1965, for STL. The major test objectives are throttling over the full range of thrust, I_{sp} performance over the full range, combustion stability over the full range of thrust, and injector/ablative chamber compatibility. At present, both contractors have unresolved problem areas in the development of their injectors. STL has not obtained a design with high performance over the full throttling range, and rough combustion stability has continued to linger. Rocketdyne has problems in the throttling phase with helium distribution, buzzing instability, and low performance at low throttle levels.

STL altitude testing has continued to be delayed by facility malfunctions. STL and Thiokol have not completed malfunction analysis requirements for release of the test facility to STL. Rocketdyne has completed checkout firing on the Block I and II engines at their altitude facilities; however, facility malfunctions have continued to plague scheduled testing.

Both subcontractors, particularly STL, have had problems with ablative chamber/injector compatibility, but these have been resolved by proper injector design, and recent tests have been very satisfactory. STL has tested numerous injector configurations and tried to spot trends which indicate the effects of varying key parameters. Rocketdyne has a new injector design (dome manifold of "3-D" design), which is an attempt to solve the helium distribution problems and the popping and buzzing instability problems. Test results received to date have not established the acceptability of this injector design.

A decision is being considered to use a supercritical feed pressurization system because of the large weight savings. The ambient system would not be immediately dropped, but would be replaced by the supercritical pressurization system as development proceeds.

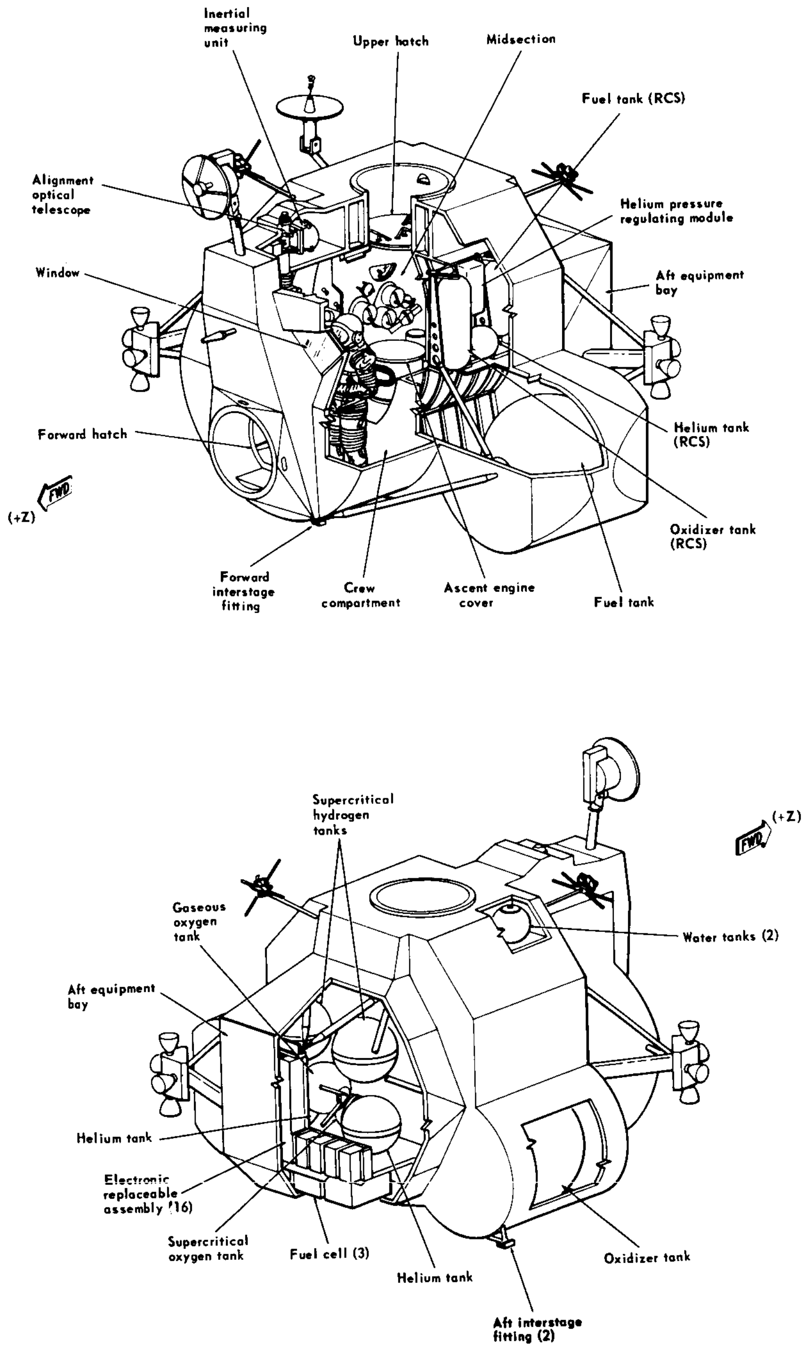


Figure 6.- LEM ascent stage.

Ascent Propulsion Subsystem

The ascent engine development program at the Arnold Engineering and Development Center (AEDC) was completed. The following series of tests were conducted:

a. Performance Verification Test Series.- Twenty-eight performance verification tests were conducted using water-cooled hardware. The first 11 firings were run with the B3-I2 injector (low injector ΔP for 120 psia chamber pressure) at the nominal L^*. The next 17 firings used the B3-1 injector (high injector ΔP for 100 psia chamber pressure) at L^*'s of 27 and 37 (addition of a 4-inch water cooled section adjacent to the injector) in order to determine the effect of the different L^*'s on performance. This was necessary for verification of the performance values of the four phase "B" ablative thrust chambers.

b. Phase "C" Thrust Chamber Evaluation.- Three phase "C" thrust chambers were tested during this series. The phase "C" thrust chambers differ from the phase "B" chambers in that a compression molded ablative throat section is used. The chamber pressure is 120 psia and the nozzle expansion ratio is 46.5 to 1. The planned firing runs of 60 seconds, 380 seconds, and 5 seconds were accomplished successfully with negligible throat erosion. Performance data showed that the nominal specific impulse was 2.0 to 3.0 seconds higher than the specification 3σ low.

c. Fire-In-The-Hole (FITH) Tests.- Eighteen FITH tests were conducted. The location of the flame shield from the nozzle exit was varied from 3 to 10 inches. The resulting shock wave penetrated to the nozzle throat for the 3-inch location, but outside the nozzle extension for the 10-inch location. Inspection of the thrust chamber showed no evidence of any adverse effects on the chamber. As a result of these tests, the propulsion subsystem development facility "FITH" test program will be reduced by approximately 50 percent.

GAEC has initiated "blowdown" tests on the BA-3 heavyweight pressurization rig. No problems have been encountered. See figure 6.

Reaction Control Subsystem

Primary efforts involved completion of the HR-3 test rig at the Magic Mountain test facility, testing of the HR-2 rig at GAEC, and completion of the ground rules for procurement of common usage components.

In addition, the Marquardt Corporation (TMC) has succeeded in reducing the chamber pressure surges (spiking) in the combustion chamber by modifying the injector. The injector is currently being redesigned (incorporating fuel valve standoff) in order to improve thermal characteristics of the thrust chamber assembly.

TMC has encountered contamination problems on the HR-3 rig at their Magic Mountain test facility. The contamination was in the area of the thrust chamber injectors and was attributed to faulty purging procedures. Purging procedures are being revised accordingly.

Firm ground rules for implementation of the common usage rule have been established by MSC and GAEC. GAEC will utilize NAA specifications with a GAEC cover sheet in order to facilitate the placement of the purchase orders for the common usage components. However, the process of obtaining NAA specifications with the latest revisions and the subsequent renegotiation with the common usage component manufactures are expected to take up to three months. Such a delay may necessitate that the first deliveries of the prototype common usage components be supplied to GAEC as government furnished equipment.

Communication Subsystem

Pulse Code Modulation and Timing Equipment (PCMTE).- To resolve the PCM and ACE interface incompatibilities, it was decided that the LEM PCM output circuits to ACE will be powered by GSE supplied voltage to provide the necessary voltage levels at the ACE inputs. This method requires minimum modification and schedule delay to the flight equipment.

A new vibration fixture for the mechanical model testing was designed and fabricated. After completion of the fixture, testing of the mechanical model was resumed. Test results have not been reported.

Service test model (STM) no. 1 was completed. Design verification and electrical checkout were performed on this model.

Special test equipment (STE) no. 1 has been completed, checked out, and used to test STM no. 1. STE no. 2 has been completed and is undergoing checkout.

Audio Center.- MSC has initiated action to implement an additional audio center mode switch position as requested by the astronauts. This mode switch position, as in the CM, will allow a hot interphone capability without RF transmission and will allow the selection of any desired communication link without excessive switching.

Pre-modulation Processor (PMP).- Hardline bio-medical data transmission has been modified from pulse code modulation to an analog subcarrier to better conserve the data handling capacity.

S-Band Equipment.- The S-band transceiver circuits have been designed and breadboarded. These circuits are now undergoing testing.

VHF Equipment.- Acceptance test procedures for the experimental models have been written and approved. VHF transmitter-receiver experimental model no. 1 was completed and is being tested.

Antennas.- At the design concept review held for the erectable antenna, Grumman approved the design proposed by RCA. Work then began on an experimental model which will demonstrate both electrical and mechanical performance.

Grumman was directed to investigate automatic switching techniques to replace the manual switching planned for the S-band in-flight antennas.

Operational Instrumentation Subsystem

In-flight Checkout.- GAEC completed an analysis of inflight checkout philosophies and equipment in June 1964. Because of the nature and number of checks required, it was recommended that necessary checkout functions be accomplished on a decentralized basis by the use of existing hardware. The on board checkout electronics assembly (OBCEA) was, therefore, deleted from systems requirements as a separate entity.

Caution and Warning Electronics Assembly (CWEA).- The proposals received in response to an invitation to quote (ITQ) for the caution and warning electronics assembly (CWEA) were evaluated, and the Arma Division of American Bosch Arma Corporation was selected as the supplier. Negotiations were initiated to compromise a reliability figure within reasonable power, weight, volume, and operational constraints. Contract target date is October 1964.

Data Storage Electronic Assembly (DSEA).- Procurement specifications were completed and ITQ were distributed for the data storage electronic assembly (DSEA) in September 1964. Operational characteristics will enable automatic voice actuation (VOX) from vehicle intercom to record dialog spoken either in the LEM or by the extravehicular astronaut (EVA). The magnetic tapes thus created will provide a permanent record of conversations.

Instrumentation/Communication R and D Subsystem

The following vehicles have been scheduled for MSC government furnished equipment for development flight instrumentation/communications subsystems:

Vehicle	Required delivery schedule to GAEC
FTA-1	January 18, 1966
FTA-2	June 27, 1966
LEM-1	November 20, 1965
LEM-2	January 12, 1966
LEM-3	March 16, 1966
LTA-1	June 18, 1965
LTA-4	October 22, 1965
LTA-7	December 18, 1965
LTA-8	December 29, 1965

LEM's 1, 2, and 3 mission requirements have recently undergone change. November 1, 1965, is the scheduled release date of a new measurement list.

Video Transmission Subsystem

Secondary Emission Conductivity.- The Vidicon Laboratory Camera was received, checked out, and evaluation was initiated. The camera will be used in support of the LEM-TV camera development.

Negotiations for the development of the LEM-TV camera were completed, and a letter contract was sent to the contractor to enable an immediate start on the program. The contractor completed the preliminary design and breadboard construction of the camera circuitry as well as the preliminary optics design.

MSC completed in-house fabrication of an experimental TV scan-converter which converts the Apollo slow scan TV signals to standard commercial TV signals. The unit was checked out; an evaluation indicates the performance is superior to that of other types. A production model of this scan-converter or a modified version will be provided for

Cape Kennedy for mission operational use. MSC personnel met with Goddard Manned Space Flight Network (MSFN) personnel to acquaint them with the operation and performance of this equipment. This equipment, already developed and indicating superior performance, is considered a logical choice for use at MSFN stations.

ADAPTER

Drawings for the spacecraft adapter were released on July 8, 1964.

Equipment for the manufacture of the aluminum honeycomb panels has been received and is being installed and checked prior to the manufacture of the first adapter.

APOLLO EXTRAVEHICULAR MOBILITY UNIT

The Apollo space suit assembly (SSA) has been redesignated as the extravehicular mobility unit (EMU). A final draft of the Apollo EMU specification is being prepared in accordance with NPC 500-1. This draft will include comments from all major areas of MSC and Apollo spacecraft contractors concerned.

Three major contractural changes were initiated by MSC Crew Systems Division (CSD). The original contract for the Apollo suit development has been extended to allow additional work in selected areas of helmet and glove development. A second contract for fabrication of eleven prototype (A-4H) training suits was let in August and delivery will be completed in November. The decision to utilize Gemini suits in the Block I Apollo flights made it possible to reduce the number of training suits from an originally scheduled twenty-seven. The third contract was for continued development of the Block II EMU, which will incorporate significant design features in the areas of shoulder mobility and configuration.

Two status review meetings were held between MSC-CSD and Hamilton Standard Division (HSD). These reviews defined in detail contractural requirements, and also include a comprehensive progress report. The major area of development by HSD during this period has been in the area of shoulder and hip mobility. An effort to increase the ranges of movement with decreasing torque requirements and shoulder dimensions is being made by the contractor. The results will be integrated into the A-5H pressure suit which will be delivered to MSC in March 1965. Three different type helmets have been proposed and mock-ups of each are being fabricated for evaluation. Two different types of palm restraints have been developed and evaluated. In conjunction with the increased effort for mobility, MSC has implemented an extensive X-ray program which is designed to examine and define interface areas of the pressure suit with the suited subject. Results have been transmitted to HSD to incorporate into their development program.

Design of the development model liquid transport portable life support system is essentially complete. Feasibility testing of critical components has been completed, and fabrication of the majority of hardware for the first delivery units has been initiated. Component subsystems development testing will begin in December 1964.

Hardware delivered during this quarter includes eight exterior mock-ups of the PLSS, two exterior mock-ups of the emergency oxygen system, one thermal garment prototype, and two liquid garment prototypes. The thermal garment prototype is being readied for thermal evaluation testing in the Ling-Temco-Vought Corporation space simulator in late October 1964. In-house evaluation of the other mock-up and prototype hardware has begun.

SPACECRAFT-LAUNCH VEHICLE INTEGRATION

Crew Safety

Design criteria for the Saturn IB emergency detection system have been agreed upon by MSC and MSFC, and they are being implemented by spacecraft contractors. The draft criteria for the Saturn V system is slightly different, and it will be considered for approval in October.

An investigation is being made of the possible use of angle-of-attack as an abort parameter to be displayed to the pilot during launch.

Electrical Power Subsystem

The initial phase of the LEM/CSM voltage compatibility study has been completed by MSC. At the present stage of development on the LEM and CSM, there is no interconnection or planned interconnection. Therefore, no requirement for compatibility of electrical system parameters exists. However, future design requirements could connect the two electrical systems in such a way that compatibility may be required. Continued efforts in the LEM/CSM electrical system compatibility study include the monitoring of LEM and CSM design to determine if any future design changes would require compatibility and a review of Apollo Mission Planning Task Force (AMPTF) results to determine if any future operating modes might require electrical system compatibility.

MSC has completed the review of the AMPTF "design reference mission." MSC agrees to use this mission as a basis for reporting the status of Apollo electrical energy and power for both CSM and LEM. MSC will continue to maintain electrical power load analyses based on the "EPS Critical Design Mission" in order to control growth within the system capabilities.

MSC has requested an extension of the existing wiring test program to establish the effect of a lunar environment upon the electrical current carrying capacity of wiring in various sized bundles. Appropriate testing will allow evaluation of the approaches taken by NAA, GAEC, and MIT.

LEM Measurement Requirements

Measurement requirements for the LEM are being formulated under a block instrumentation concept. LEM 1, 2, and 3, comprise one block and LEM 4 through 10, another block. The lunar test articles (LTA) (vehicles for ground tests) and two flight test articles will be individually instrumented.

A LEM 4 through 10 measurement requirements list is in publication. The requirements have been coordinated within MSC and the LEM contractor. The list is approximately 86 percent complete and will be updated as more data becomes available. The measurements for the stability and control area are approximately 50 percent defined. The LEM 4 through 10 list contains requirements for approximately 800 parameters; 400 of which are to be telemetered. Approximately 70 additional parameters will be added as a result of the stability and control definitization.

The measurement requirements for LEM 1, 2, and 3 are being prepared, and they are scheduled for completion by November 1, 1964. The LTA's measurement requirements will be forthcoming 30 to 90 days later.

Electrical/Electronics Packaging

On July 1, 1964, directions were issued to NAA which updated humidity/contaminant design and test criteria for equipment within the command module (CM). Airframe 008 is the first vehicle affected by this requirement.

After a one-month study to determine the feasibility of utilizing a lower equipment bay environmental curtain (LEBEC) to protect electrical/electronic equipment, this proposal was rejected by NAA and MSC.

On July 31, 1964, MSC personnel reviewed the proposed Block I CM "humidity-fix" for electrical/electronic equipment. Generally, the proposed protection techniques were considered adequate. However, the following were identified as problem areas:

a. Humidity protection for S-band transponder and up-data link.

b. Humidity/contaminant protection for entire CSM during all ground phases with emphasis on equipment located external to the CM cabin.

c. Lack of adequate qualification of spacecraft harnesses.

d. EMI within SCS.

NAA was directed to reconfigure the CM lower equipment bay with the "ring-mount." This configuration discards inflight maintenance, utilizes repackaged electronics into higher but smaller (in volume) boxes which are fastened to the cold plates with through-bolts rather than clamps, saves weight, improves humidity protection, and incorporates redundancy and functional requirement changes. At this same time, NAA and MIT were directed to hermetically seal electrical/electronic equipments. In isolated instances in which performance, weight, cost and/or schedule might be seriously compromised by utilization of hermetic sealing, MSC will review alternate proposals and waive the hermetic specification when it is deemed desirable.

Electromagnetic Compatibility

The electromagnetic compatibility program for NAA was revised, and EMC testing of spacecraft equipment will be limited to one of a type. If significant changes or modifications are made, further testing may be necessary. EMC testing of GSE shall be limited to one of a type "mission essential" GSE as approved by NASA. MIL-I-26600 and MSC addendum MSC-EMI-10A are the MSC-EMC controlling specifications. NAA has been permitted to use the NAA-EMC specification as an interpretation of the MSC-EMC specifications.

Instrumentation and Communications

The instrumentation and communication interface control documentation (ICD) for SA-6 and SA-7 was completed and signed by MSC and MSFC. The ICD for SA-201 is expected to be completed by October 19, 1964. The frequency plan for the Saturn IB program was completed and signed by MSC and MSFC.

DESIGN INTEGRATION

LEM Umbilical Relocation on Spacecraft LEM Adapter (SLA). - The radial location of the LEM umbilical plate on the SLA was changed in order to prevent a major redesign of the Complex 39 launch umbilical tower (LUT) instrument-unit (IU) swing arm. The nominal position of the umbilical plate was changed from 53° from the -Z axis toward the +Y axis to 73° from the -Z axis toward the +Y axis at station X_A 608.25. This umbilical relocation is effective on all launch pads.

Command Module (CM) Access Hatch. - A functional mock-up of the CM access hatch was installed on the Block I CM mock-up for review by MSC. Egress trials with this mock-up indicate that the average time for egress of the center crewman is less than 45 seconds. NAA has been requested to update the mock-up to include the boost protective-cover egress provisions as well as the minor design changes which have resulted from the MSC review. They will also be included in the Block II CM hatch design. It is expected that this work will be accomplished by mid-December 1964.

Thermal Control. - The environmental control subsystem (ECS) radiator will be redesigned to incorporate the selective stagnation concept. This concept utilizes fluid stagnation in the radiator tubes under lower load conditions to allow a wider load variation. This will circumvent the freezing problems of the present design. The area will also be increased to accommodate a substantial increase in heat rejection requirements. The increase will also limit water boiling in lunar orbit such that water may be transferred to LEM, thus reducing LEM injected weight.

The thermal design criteria for the spacecraft has been redefined to eliminate the severe "worst case" requirement. The new criteria establish a specific sequence of orientation with a limited time of "worst case" operation for each subsystem to provide required spacecraft operational flexibility.

Weights. - The CM weight increase, shown in table I, is a result of revision to the estimates for the Block II changes. Additional weight changes are due to the addition of ballast required to maintain the desired L/D ratio. Other revisions accounting for weight variations are increases in flotation system, addition of a postlanding ventilating system, addition of partial display computer controls, and various structural changes and modification.

Service module weight changes for the reporting period are revisions of Block II estimates. Increases in weight also reflect the revision of the residuals to eliminate the GSE propellant loading instrument error

~~CONFIDENTIAL~~

TABLE I.- APOLLO SPACECRAFT WEIGHT STATUS

LUNAR ORBIT RENDEZVOUS MISSION

		Control weight pounds		Current status pounds	Change from last report
Command Module		11,000		10,090	(60)
Service Module					
Inert	10,200		10,050		-70
Usable Propellant - Translunar (ΔV_1 = 3,870 fps Isp = 313 sec)	28,440		27,677		612
Usable Propellant - Transearth (ΔV_2 = 3,915 fps Isp = 313 sec)	10,070		9,567		-3
TOTAL		48,710		47,294	(539)
Lunar Excursion Module					
Descent Stage					
Inert (Includes Residuals)	3,865		3,987		187
Usable Propellant (ΔV_3 = 7,385 fps Isp = 301 sec)	15,975		15,917		742
Ascent Stage					
Inert (Includes Resuduals)	4,650		4,581		141
Usable Propellant (ΔV_4 = 6,646 fps Isp = 303 sec)	5,010		4,946		256
TOTAL		29,500		29,431	(1,326)
Adapter		3,800		3,700	(225)
Total Spacecraft Injected Weight		*93,010		90,515	(2,150)
Launch Escape Subsystem		8,200		7,945	(435)
TOTAL SPACECRAFT LAUNCH WEIGHT		101,210		98,460	(2,585)

*Allowable Injected Weight 94,000

~~CONFIDENTIAL~~

from the burnout weight. Other changes during the reporting period were due to relocation of equipment from Sector I and miscellaneous environmental control weights.

The weight change for the launch escape subsystem was because of increases in the boost cover and canard installation and reductions in required ballast which are consistent with CM weight changes.

The weight increases in the LEM during the reporting period are due to addition of the transponder antenna and wave guide, redefinition of GFE, revision of the LiOH system, and relocation of equipment. Additional weight changes are the results of the recalculation of vendor weights, revision of the electrical supply system as a result of addition of a battery, and recalculation of reactant and reactant tankage.

The above changes in the LEM are inert weight changes and have caused changes in the required ascent and descent stage propellants.

CREW INTEGRATION

Command Module

A major effort was put forth on the Block II command module redesign with the major consideration being given to the guidance and control system controls and displays.

a. A basic functional concept was used, and many of the guidance and control system switching functions were brought to the control panel. Thus, the net results were major changes to the flight control system controls and displays as well as a large increase in system operational flexibility.

b. A second flight director attitude indicator (FDAI) was added to Block II with the capability of being driven from either the inertial measuring unit or the body mounted attitude gyros (BMAG) to increase the crew's operational flexibility.

c. Block II will have only one translational controller, as opposed to two in Block I, with equivalent reliability built into internal redundancy of the controller.

A soft mock-up of Block II, with a silk screen control and display panel, was reviewed on September 30, 1964. Most of the problems concerning the panel had been worked out between NAA and MSC with respect to the functional arrangement of the flight control switches. However, some additional attention to controls and displays will be required prior to the hard mock-up review scheduled for February 1965.

The MSC attitude controller functional specification for CM and LEM was firmed up on September 10, and ASPO has submitted appropriate directions to the contractor.

The entry monitor system (EMS) concept was altered to a scroll type instrument with a choice of six entry profiles and a single plane scribe. The EMS has been eliminated from Block I vehicles.

A Block I CSM crew compartment lighting mock-up review was held at NAA on September 3, 1964. The lighting concept was considered adequate for Block I vehicle utilization with certain noted exceptions which the contractor will rectify.

Lunar Excursion Module

In July 1964, a review of the internal LEM lighting was held at GAEC. The electroluminescent (EL) integral lighting with associated flood lighting, demonstrated on the TM-1 mock-up, was evaluated by MSC and found to be conceptually acceptable. Final acceptance of the EL lighting will be granted when production hardware is demonstrated to be equal or better than that shown during the initial lighting review. The October M-5 mock-up will have more advanced EL lighting system than that shown on the TM-1.

An extensive review of the onboard timer requirements for the Apollo mission was conducted by MSC. The results of this review indicated the display requirements for a digital event timer and an analog mission timer in lieu of the analog event timer and a GMT clock. The CM and LEM digital event timer will be functionally common. All time reference for the Apollo mission will be in hours, minutes, and seconds.

A review of the display requirements for the propellant quantity of the descent and ascent propulsion systems was conducted. The results indicated that there is an operational requirement for continuous monitoring of descent propellant quantity. A major change in LEM design eliminated the forward docking tunnel and added an overhead window for the command astronaut.

TRAINING

Training Equipment

A cost study was conducted at NAA to recommend reduction of Apollo trainer expenses and to improve delivery schedules. The following recommendations resulted:

a. Complete Apollo part task trainer in a simplified launch and reentry configuration.

b. Maintain contracted schedule for Apollo mission simulators (AMS).

c. Initiate an action plan to minimize delays in supplying flight controller training.

A letter of intent has been given to Link Aviation by GAEC for construction of two LEM mission simulators. Negotiations were conducted between GAEC and Link during July to define the contract.

The contractor trajectory-interface task group, formed to implement the AMS/MSCC interface, has met six times within the past three months and has submitted preliminary recommendations for booster malfunction control, data transfer requirements, timing, and coordinate systems.

A task group (NASA/GAEC/NAA) was formed to implement the LMS/AMS interface. The first meeting will be held in October.

Systems Training

Fabrication of the CSM systems trainers was initiated. There has been considerable coordination with NAA-S&ID in the areas of spares support, test and acceptance procedures, and the use of instructor personnel for systems courses. Ground work for the generation of the Apollo systems trainer test and acceptance procedures has been completed. NAA-S&ID has submitted an overall plan to MSC, and NAA-LAD is preparing a list of the specific trainer operational tests.

The Apollo ECS, electrical, SCS, and sequential trainers should be ready for delivery to MSC in early December 1964. The Apollo propulsion systems trainer should be ready for delivery to MSC during January 1965.

ENGINEERING SIMULATION

A program review was carried out at NAA, resulting in reductions in personnel and simulation facilities to reduce costs. NAA will have a hybrid-systems simulation computing facility capable of tie-in to either of two command module mock-ups with prototype displays, controls, and furnishings. They will also have a G&C laboratory with analog computer capability for closed-loop evaluation of systems hardware. An extensive entry-modes simulation study was completed at NAA in which stabilization and control system failure modes and corrective actions were evaluated.

Preparations are being made at Grumman for two large simulations. One (IIB) will cover the descent, ascent, and abort phases of the LEM mission; and the other (IIIB) will cover the hover, landing, separation, and docking phases. The hybrid computer portion of IIB, without cockpit or visual displays, has been in operation since early August as a real-time analytical facility. The lunar terrain models and visual display equipment are being assembled. They are expected to be in operation in January 1965, and will serve as the main systems evaluation tool at Grumman until the full mission engineering simulator becomes operational. The full mission simulator will use the same visual display systems, but will have more detailed systems simulation and actual hardware tie-in.

MIT is implementing a combined hardware-software-cockpit type simulator for CM and LEM for more complete evaluation of their systems design. A CM mock-up with prototype display and control equipment is presently tied-in to simulation computers. Optical subsystem equipment is being added to evaluate navigation-sighting crew tasks and performance.

MSC activities included installation and checkout of a virtual-image window display system which is used to conduct a simulation of the LEM landing and touchdown to evaluate design criteria.

A closed-loop simulator evaluation of Little Joe II flight control hardware was carried out.

The Langley Research Center full scale docking simulator has been in operation for the top hatch LEM active docking since September 14. Astronauts and FCSD pilots have been participating in the simulation. The objective of the study is to establish piloting procedures for overhead docking using various sighting aids and under different lighting conditions.

GROUND SYSTEMS ENGINEERING

ACCEPTANCE CHECKOUT EQUIPMENT - SPACECRAFT

The ACE/SC Station No. 1 at NAA, Downey, was accepted. Also, the ACE-SC station development engineering inspection (DEI) was completed on September 23, 1964. There were 16 requests for change (RFC) items submitted. None of the submitted RFC items were requests for design change, which indicated conformance with ACE-SC systems specifications and requirements.

It has been determined that the G&N accelerometers will be monitored with an oscilloscope which will be installed in the ACE-SC G&N consoles. This will consist of displaying the 3200 cps monitor signals from the pulse integrated pendulum accelerometer (PIPA) loops, and it will allow check-out similar to that established on other programs.

The servicing equipment adapter (C14-240) and the servicing equipment digital test command system (C14-241) have been relocated from the launcher umbilical tower (LUT) to the mobile arming tower (MAT) for Cape Kennedy operations resulting in significant operational advantages because it will not require disconnection of approximately 100 cables (60 conductors each) when the MAT is removed.

GROUND SUPPORT EQUIPMENT

During this quarter NASA has evaluated the requirements for 157 models of GSE submitted by NAA for contractural coverage. These included newly defined models as well as quantity changes in previously approved models. The direction to NAA with respect to the 157 submittals was 84 approved, 27 approved with quantity change, and 46 disapproved.

Since July 1, 1964, there have been a total of six GSE requirements reviews held; three at GAEC, and three at NAA. During the GAEC requirements review, requirements for 58 newly identified models were evaluated. NAA approved 38 models and disapproved 20. At the NAA requirements reviews, requirements for 83 newly identified models were evaluated. NASA approved 55 new models and disapproved 28.

Logistics.- The Apollo "black-box" sparing policy was implemented for all Apollo contractors. The policy states that electrical and electronic flight hardware is to be spared to the "black box" level. All other flight hardware and GSE will be spared to the lowest serialized replaceable unit. The nominal spares to be provided for flight hardware are three complete systems plus one equivalent system.

Transportation requirements for Apollo were reviewed to insure adequate transportation for the program. A need for a backup aircraft to support the B-377 PG was recognized, and a request for an additional B-377 PG was forwarded to NASA Headquarters. Studies were made to determine the most feasible mode for transporting the LEM adapter. Studies indicated that the helicopter mode was most desirable and the Army has been requested to provide support to MSC with a CH-46A helicopter prior to December 1964.

Electrical.- During the GAEC concept reviews a total of 19 GSE models were reviewed; NASA approved 9 models without change, and 10 models were disapproved. At the NAA concept reviews a total of 98 GSE models were reviewed; 67 were approved and 31 disapproved. Also, during this period, MSFC has agreed to furnish all d-c power supplies to satisfy MSC requirements at launch complexes 34 and 37B. MSC must perform functional and acceptance check-out on these power supplies.

Location of the GSE servicing equipment for pad 34 and pad 37 has been completed. Six transfer units and the associated controls will be located on the MAT at launch pad 39. The units are the helium, liquid-hydrogen, and liquid-oxygen transfer units and the RCS oxidizer, SM RCS fuel, and CM RCS fuel servicing units.

As a result of a study to reduce the total NAA GSE task, 24 GSE models were deleted and the number of other models was reduced by 87 units. This reduction in GSE was made possible by supplying certain items of GSE as government furnished property (GFP), by a change in program philosophy, and by the time-sharing of available equipment.

The design concepts of 71 mechanical models were reviewed during this period. Of the 53 items presented by NAA for reviews; 36 were approved, 10 deleted due to lack of requirement for the equipment, and 8 items are being held pending presentation of new concepts. Nineteen concepts were presented by GAEC. NASA approved 10 items and disapproved 9.

CHECKOUT

As a result of the early availability of the ACE-SC systems, the requirements for most of the NAA special test units (STU) were reevaluated to save funds and avoid duplication of engineering effort. After an analysis of the 47 STU units scheduled for the Apollo Program, it was determined that 36 of the units could be deleted. NAA was directed to supply three units for initial utilization at NAA Downey and eight units at PSDF. One of the Downey units will ultimately be shipped to PSDF. This utilization study resulted in elimination of STU equipment at MSC and at Cape Kennedy.

On September 16, 1964, the Eastern Test Range (ETR) released launch complex 16 to NASA for use as a service propulsion subsystem test facility and static firing stand. Work has been initiated by NASA and NAA to start modification of the facility, to make maximum use of existing pad GSE, and to define any additional GSE requirements.

A decision has been reached on the radar boresight facility test requirements. The radar will be boresighted as a system, and there is no requirement to run an end-to-end check with the entire flight control system operating. This will reduce the test complexity at the boresight facility, and all end-to-end flight control systems checks will be performed in the O&C building.

The basic checkout sequence for AFRM 009, 011, and 012 has been defined. The overall checkout time for 011 and 012 through launch is 96 days. Because the fuel cells and cryogenic tankage have been deleted on AFRM 009, the overall checkout time is approximately 82 days.

The command module and service module RCS will not be static fired as part of the prelaunch checkout. The RCS will be given low- and high-pressure gas checks. Referee propellants will be used to evaluate the flow characteristics of the RCS system at ETR.

The basic concept and sequence for servicing the LEM and CSM have been defined. One control unit (C14-241) will be used concurrently by LEM and CSM. Transfer of control between LEM and CSM will be performed by the NASA test conductor from the ACE-SC control room at the O&C building. Both contractors will be able to monitor the status of all servicing equipment during the transfer of propellants and cryogenics.

OPERATIONS PLANNING

LUNAR MISSION PLANNING

During this quarter, the joint Contractor-NASA mission planning study has selected a design reference mission which will form a basis for weight reporting, reliability modeling, crew task analyses, and mission-related studies. The trajectory for this mission is complete, and a detailed sequence-of-events (beginning with rollout from the vertical assembly building) is in preparation.

Trajectory studies have been completed for representative abort situations throughout the lunar landing mission.

A systematic analysis of the mission-related functional design requirements for each spacecraft subsystem has been initiated. As a part of this task, the present subsystem designs are being assessed for their adequacy in meeting these requirements for both nominal and contingency situations.

Major emphasis during the next quarter will be placed on a completion of the analysis of the subsystem functional requirements and integrating these requirements into the spacecraft specifications.

Emphasis will also be placed on developing detailed sequence-of-events for representative abort profiles and updating the present design reference mission to reflect recent changes.

Apollo System Specification

MSC is continuing the studies on differences between the MSF specification and current spacecraft design. At present there are two known discrepancies and nine design objectives in the MSF specification. During the last quarter, the following studies have been completed, and the Apollo Spacecraft Program Office (ASPO) has formally requested the MSF to revise the system specification accordingly:

a. The requirement for reducing the velocity of the command module (CM) to less than 30 ft/sec by the time of touchdown was deleted and replaced by the following requirement: "The earth landing system shall be designed such that the crew tolerances to impact loads shall not be exceeded under any design combination of rate of descent, CM attitude at impact, or horizontal velocity for both land and water landings."

b. The requirement for CM flotation in sea state-6 water environment has been deleted and replaced by the following requirement: "For water landings, the structure shall be capable of a safe landing in an environment of wave heights to 8.5 feet, wave slope to 8.4 degrees, and wind velocity to 28.5 knots. The CM shall remain afloat, capable of being recovered, for a minimum of seven days following touchdown considering weather conditions up to 40 knot winds and wave heights to 18 feet."

c. The requirement for a survivable environment and necessary provisions for 3 men for 7 days after landing on earth or water has been deleted and replaced by the following: "After touchdown on water the CM shall provide a habitable environment with necessary provisions for 3 men and operation of recovery aids for a period of 48 hours."

d. The requirement for 50 percent excess atmospheric gas supply for the CM and LEM has been changed: "The CSM and LEM shall provide the atmospheric gas necessary to sustain the CSM and LEM metabolic, leakage, repressurization, and portable life support subsystem (PLSS) recharge requirements for a nominal 14 day (LEM 48 hours separated) lunar landing mission. Alternate or redundant atmospheric oxygen storage supply systems shall be provided in the CSM and LEM which, when used under approved emergency operating procedures, shall allow for safe aborts.

During this quarter a NASA Letter to NAA provided the mission objectives for Mission 201 which delineated the first, second, and third order objectives.

Another NASA Letter to NAA provided additional details on Apollo mission 202 (CSM 011) to permit NAA to proceed with the design of the spacecraft programmer. The letter delineated first, second, and third order objectives for mission 202. It also provided a preliminary mission description, sequence-of-events, trajectory profile and ground tracking station support that are expected to be available.

An MSC TWX to GAEC provided preliminary mission definitions for missions 206 through 210 (LEM's 1 through 5). LEM 1 is to have a primary unmanned mission and an alternate manned mission. The subsequent LEM's were to be primarily manned with alternate unmanned capability. All LEM's flown on Saturn V launch vehicles are to be planned to be manned and operated by the LEM crew after transfer from the CSM.

An Apollo support group (ASG) letter established objectives and profile requirements for spacecraft missions on 501 and 502, and requested ASG to provide a preliminary mission trajectory profile.

Launch Time Constraints

Studies relating to the environmental constraints on the earth launch have been completed and the report is in preparation. Results indicate that a combination of all the proposed launch constraints virtually eliminate all possible launch opportunities, thus some of the more restrictive constraints will have to be examined in more detail and possibly eliminated. The spacecraft performance flexibilities will be examined next to determine if the launch constraint problems can be alleviated.

FLIGHT TEST PROGRAM

Significant agreements from the ninth meeting of the MSC-MSFC flight mechanics, dynamics, guidance, and control panel held at MSFC in July are summarized as follows:

a. The roll-rate setting for the emergency detection system (EDS) should be reduced from 40°/sec to a value between 20°/sec and 5°/sec. Preliminary studies indicate that the maximum expected roll-rate for a normal mission for Saturn IB and V will be about 5°/sec, while the physical limitation of the present MSFC rate gyros is 20°/sec.

b. Sign-off dates for flight mechanics panel interface control documents (ICD) were defined for Saturn I, IB, and V vehicles through SA-503. No ICD will be published by the panel on SA-8, 9, or 10, because of the limited interface existing for these vehicles.

c. There is no requirement to retain the launch escape system (LES) beyond normal LES jettison time in order to provide LES abort capability in the event of no S-II second plane separation. This agreement is based on the absence of any immediate catastrophic event resulting from no S-II second plane separation.

d. The type of SA-201 profile defined in MSC Internal Note 64-FM-20, "Project Apollo Preliminary Mission 201 Trajectory Profile," is acceptable to MSC and MSFC from the flight mechanics, dynamics, guidance and control viewpoint. This is a suborbital lob-type (300 n. mi. apogee) profile with a range of 4,600 n. mi. and a time from lift-off to splash of approximately 2,700 seconds. This results in a touchdown point about 250 n. mi. east south east of Ascension Island. A maximum total heat rate in excess of 250 Btu/ft^2/sec was achieved at an earth-fixed entry velocity of about 27,000 fps and a relative flight-path angle at entry of about -10°. The maximum total load factor at entry was 16g and the maximum total heat load was slightly in excess of 11 000 Btu/ft^2.

e. Until further notice, Saturn IB and V performance will be quoted for a LES jettison system weight of 8200 pounds. Nominal jettison time for Saturn V is 35 seconds after J-2 engine ignition of the S-II stage. Saturn IB nominal jettison time is under review and is approximately 20 seconds after J-2 engine ignition of the S-IVB stage. (See tables II and III.)

SPACECRAFT TEST

GROUND TEST ARTICLES

Boilerplate 27 — Second Dynamic Test Article

Fabrication of the CM, SM, and launch escape subsystem (LES) was completed. A design engineering inspection (Type IV) was held on September 17, 1964.

The CSM will be shipped to MSC in early October 1964 for vehicle shell and panel modal testing. The LES and CSM will be delivered to MSFC prior to February 1, 1965. The BP-27 adapter is scheduled for delivery to MSFC by January 15, 1965. Current status indicates that this schedule, which supports MSFC dynamic testing, will be met.

Boilerplate 14 — House Spacecraft No. 1

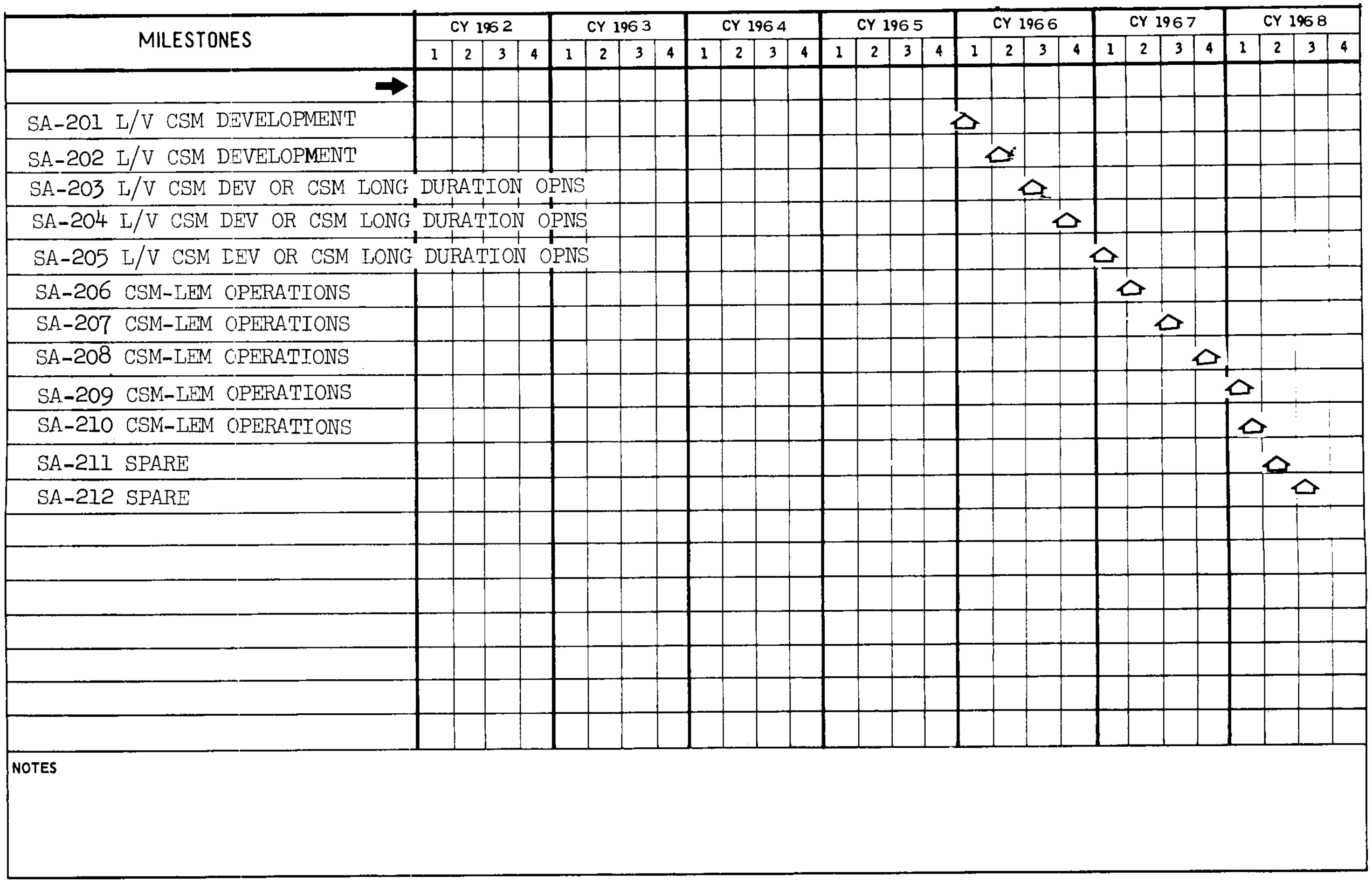
Installation of systems tubing and wiring harnesses was completed and the vehicle was transferred to the custody of S&ID Apollo Test Operations. The electrical power (EP) and environmental control (EC) subsystem installations were completed (less fuel cells and flight crew support). Individual systems tests on these subsystems are in progress. EPS tests will be completed to the extent planned upon completion of the water-glycol subsystem operations.

Communications and flight instrumentation, reaction control, and service propulsion subsystem components are being installed concurrently with testing on a non-interference to test basis. Installation and individual system checkout of the above subsystems are planned to be completed during late November 1964 and are on schedule at the present time.

Leakage in the water-glycol loop of the subsystem has caused some difficulty. Replacement of defective cold plates and the repair of

[redacted]

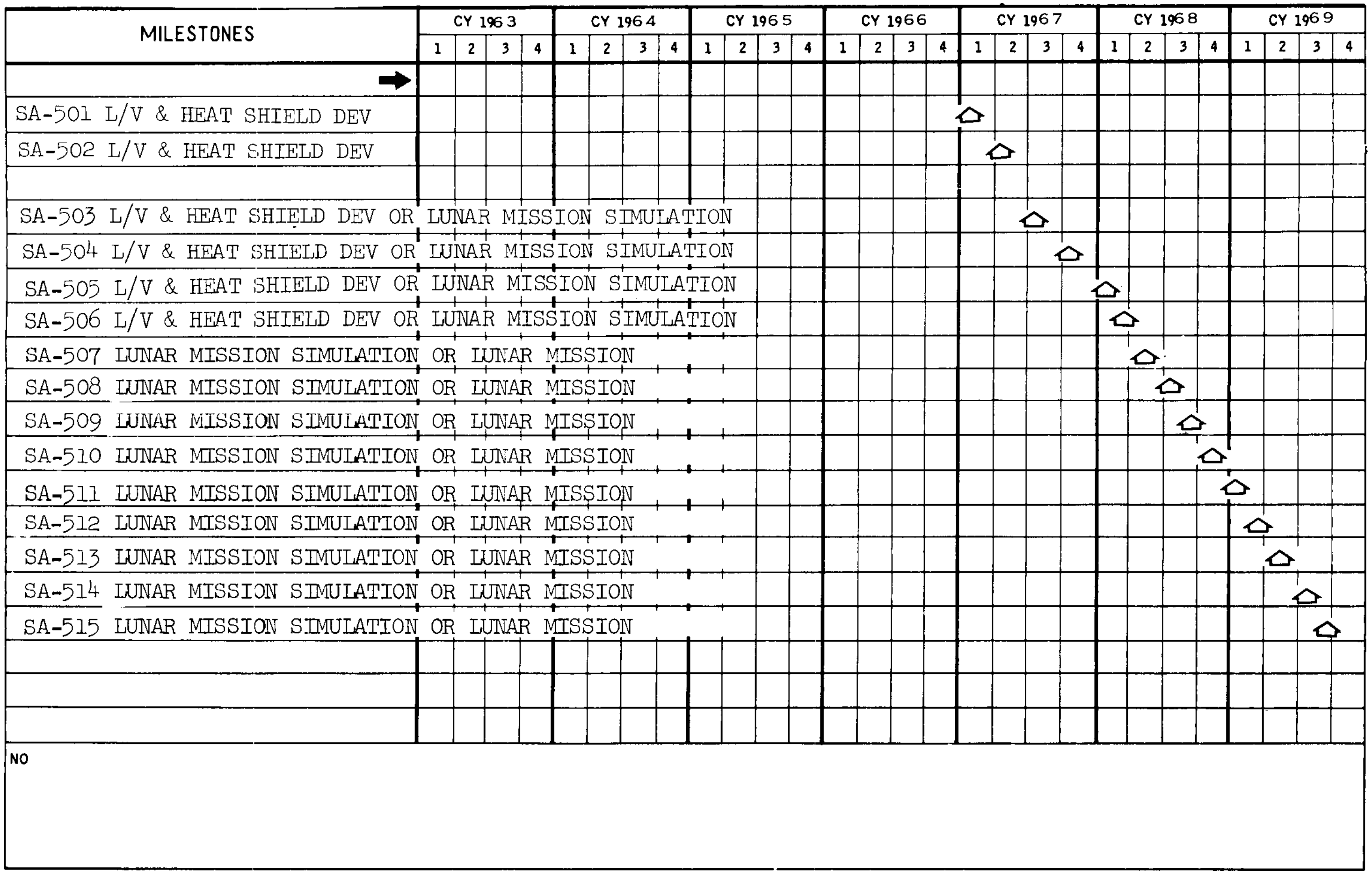
TABLE II.- APOLLO SATURN IB LAUNCHES (AS OF SEPTEMBER 30, 1964)



NASA FORM 797 DEC. 62

[redacted]

TABLE III.- APOLLO SATURN V LAUNCHES (AS OF SEPTEMBER 30, 1964)



NASA FORM 797 DEC. 62

system tubing joints has been accomplished, and the system is currently operating satisfactorily.

Airframe 006 – House Spacecraft No. 2

Fabrication of structural details has been completed, and the structural subassembly is progressing.

Manufacturing problems were encountered in the bonding of the secondary structure to the CM pressure vessel. The bonding process specification has been revised and non-destructive testing has been performed on assembled parts. Reworking of defective bonds in in progress at this time. Vehicle fabrication is estimated to be approximately 7 weeks behind schedule.

Fit-check of the ablation substructure was completed, and the substructure was shipped to AVCO in July on schedule. AVCO reports the installation of ablative material is progressing as planned. Reshipment to NAA is expected to be on schedule.

Airframe 001 – Service Module Combined Systems Test Vehicle

Airframe 001 is a flight type service module which includes the following subsystems: structure, service propulsion, reaction control, electrical power, and cryogenic gas storage. The primary mission of this test vehicle is design verification of the flight type hardware of the subsystems followed by integrated testing of the combined subsystems. Performance characteristics will be evaluated in support of the unmanned and manned flight mission. Verification of the Apollo ground support equipment is also an objective of the Airframe 001 test program. The test program will be conducted in the Propulsion Systems Development Facility at WSMR.

Airframe 001 is in its final stages of subsystems installation within manufacturing. It is anticipated that manufacturing will be completed on October 15, 1964, which will be followed by a development engineering inspection on October 16, 1964.

The test plan for Airframe 001 is scheduled to be released by NAA-S&ID by October 15, 1964. Testing of this vehicle is scheduled to start in the first quarter of 1965. Late delivery of GSE could delay the start of the test program; however, the contractor is making an effort to expedite delivery of the GSE.

Airframe 008 – Spacecraft for Environmental Test

The AFRM 008 CM inner-crew compartment is in the honeycomb bonding tool and is scheduled for closeout welding in November. The SM aft bulkhead and radial beams have been installed in the first assembly tool. Heat-shield (H/S) tool changes, required by Block I development engineering inspection changes, were completed in mid-September. The H/S is scheduled to be completed in April 1965.

An acceptable AFRM 008 test philosophy was agreed upon between NAA and MSC during September. NAA is scheduled to release the program plan which received preliminary review by MSC in October.

The MSC thermal vacuum chamber for AFRM 008 testing has experienced structural problems, and support of the test schedule is now dependent on an accelerated work schedule for effecting the necessary repairs.

Airframe 007 – Modal Acoustic Test Vehicle

Modal testing previously assigned to AFRM 007 was reassigned to AFRM 006 and reduced in scope. AFRM 007 will now support acoustic and water impact tests, postlanding qualification, and egress procedures development and training.

Airframe 004 – Static Structural Test Vehicle

As a result of the deletion of AFRM 005 from the ground test program, thermal testing was assigned to AFRM 004. AFRM 004 will now support both thermal and structural testing.

Boilerplate 28 – Earth Landing Test Bed

Assembly of the vehicle was completed, and it was delivered to the NAA Engineering Development Laboratory 4 weeks behind schedule. Control weight, vehicle closure and sealing, and couch design changes have necessitated modifications to the vehicle. These modifications will delay the first test drop until October 29, 1964. A pretest review will be held at NAA on October 6 and 7, 1964.

Boilerplate 29 – Flotation Test Vehicle

The vehicle is progressing on schedule. The majority of drawings have been released and subassembly fabrication is in progress. The boilerplate fabrication jig was sent to NAA, and it is in the process of verification prior to the start of major assembly work. Egress training and the preliminary flotation phase previously planned were reassigned from the BP-29 test program to AFRM 007.

Airframe 005 – Thermal Structural and Land

Impact Test Vehicle

This vehicle was deleted from the program. Thermal structural tests will be performed on AFRM 004. Land impact test will be performed on BP-28.

KSC and MILA Facilities Verification Hardware

NAA-CSM and SLA. - The NAA proposal for provision of facility verification hardware was approved by MSC and contracturally implemented in August.

Mock-up M-11 and the Tulsa spacecraft LEM adapter, provided for helicopter carry studies, will be modified to meet the requirements for the facilities verification vehicle. Fluid test sets will be supplied externally for verification of fluid system performance.verification of fluid system performance. Major modifications to M-11 and the Tulsa adapter will be performed at Downey and Tulsa. Minor modifications and fabrication of the fluid test sets will be done at Cape Kennedy. Current planning is for the delivery of all major parts of the NAA facilities verification hardware to Cape Kennedy by .nuary 1965. Kit definition for facility verification hardware is currently in process, and work on a test plan, to be completed in late October, has been initiated.

GAEC-LEM. - A preliminary proposal for provision of facility verification hardware was received from GAEC in June 1964. The proposal was reviewed and accepted with minor modifications by MSC.

Plans for implementing activation of the LEM facilities at MILA, including schedules for activation and a firm proposal for facility verification, were transmitted by GAEC to MSC in late September 1964. Review of this proposal should be complete by mid-October.

GAEC proposed the use of FTA-1 for verification of the launch complexes, use of a mock-up for verification of MILA industrial areas, and the use of heavyweight propulsion rigs for verification of the propulsion stand. Fluid test sets will be supplied for verification of fluid systems.

FLIGHT TEST ARTICLES

Boilerplate 22

Boilerplate 22 will be a high altitude abort test conducted at White Sands Missile Range. It is now scheduled for May 15, 1965. The abort will be initiated at 110 000 feet altitude (msl) which will approximate the upper limit for operation of the canard subsystem.

BP-22 will utilize an attitude stabilized Little Joe II launch vehicle with a 3-2 or 3-3 Algol motor configuration. Thrust termination will not be required to achieve the objectives for this mission.

The following configuration changes from previous boilerplates will be included in the BP-22 flight test: the command-module boost protective cover will incorporate spacecraft design configuration windows and protuberances; the forward heat-shield apex cover thruster system for jettison of the apex cover will be utilized; the addition of active reefing with an 8-second reef time from the dual drogue parachutes; and the modified R-7118 ring-sail main parachutes with mid-panel skirt reefing, 75 percent open fifth ring, reduction in size to 68 gores, and 8-second active reefing time.

All engineering and hardware is on schedule for meeting the launch date.

Boilerplate 23

Boilerplate 23 was delivered to NAA Apollo test and operations (ATO) at Downey by NAA Manufacturing during the last week in June 1964.

Checkout was completed approximately September 10, 1964, and the vehicle was shipped to WSMR 10 days later. Field checkout began with assembly and weight and balance measurements in the vertical assembly building. It will be completed with electrical checkout in a mated condition with the Little Joe II at the launch pad during mid-November. Scheduled launch date is December 8, 1964. See figure 7.

Little Joe II launch vehicle 12-51-1 will be utilized for the BP-23 mission. This will be the first attitude stabilized launch vehicle flown. Predelivery acceptance tests at the factory began during the first week of August and were completed on September 13, 1964. The launch vehicle arrived at WSMR on September 18, 1964. Subsequent launch vehicle buildup and checkout are to be commensurate with a mate-date of mid-October.

See tables IV and V for launch schedules.

NASA-S-64-1710

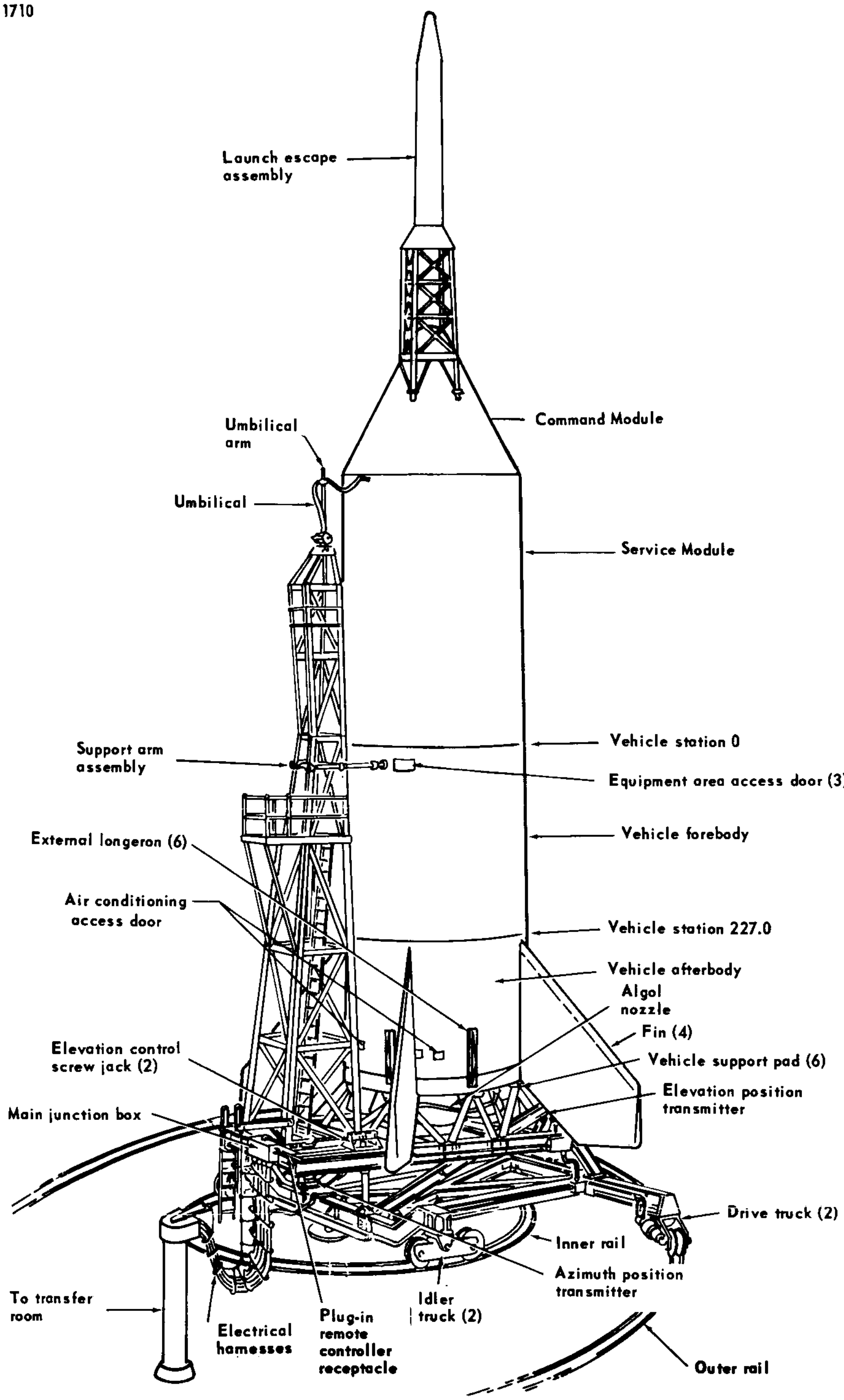


Figure 7.- Little Joe II launch vehicle.

TABLE IV.- APOLLO PAD ABORT AND LITTLE JOE II LAUNCHES (AS OF SEPTEMBER 30, 1964)

MILESTONES	CY 1963												CY 1964												CY 1965											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
→																																				
PA-1 (BP-6) LAUNCH ESCAPE SYS QUAL											▲																									
LJ II-1 LAUNCH VEH QUALIFICATION								▲																												
LJ II-2 (BP-12) TRANSONIC																																				
LAUNCH ESCAPE																																				
SYSTEM DEVELOPMENT																	▲																			
LJ II-3 (BP-23) MAX Q ABORT																								△												
LJ II-4 (BP-22) HIGH ALT ABORT																													△							
LJ II-5 (AFM-002) INTERMEDIATE																																				
ALTITUDE ABORT																																	△			
LJ II-6 (AFM-010) PAD ABORT OR																																				
BACKUP FOR FLIGHT ABORT																																				
(NOTE 1)																																				△ 2-1-66
LJ II-7 (AFM-024, BLK II CSM)																																				
ABORT QUAL (NOTE 2)																																				
LJ II-8 (AFM-026, BLK II CSM)																																				
ABORT QUAL (NOTE 2)																																				

Notes: 1. AFM-010 and LJ II-6 LAUNCH VEHICLE ARE PROVIDED AS A POSSIBLE BACKUP FOR BP-23, BP-22 or AFM-002. REWORKED BP-23 WILL BE MADE AVAILABLE FOR PAD ABORT IN CASE AFM-010 IS REQUIRED FOR A BACKUP FLIGHT ABORT MISSION.

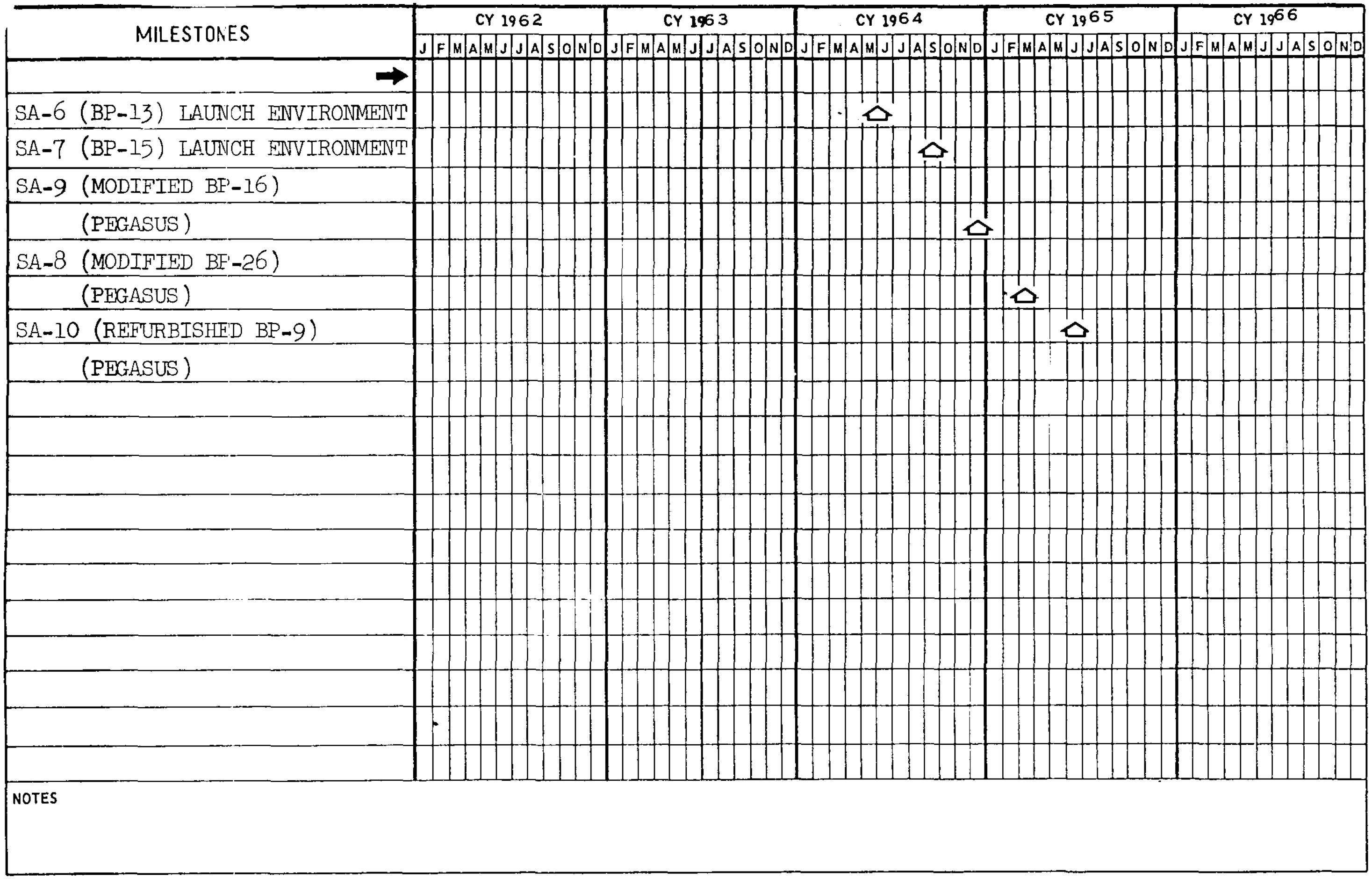
2. LJ II 7 & 8 WILL BE LAUNCHED IN THE FIRST AND SECOND QUARTERS OF 1967. THE NEED FOR THESE FLIGHTS WILL BE DETERMINED WHEN BLOCK II CONFIGURATION IS DEFINED.

NASA FORM 795 DEC. 62

[redacted]

[redacted]

TABLE V.- APOLLO SATURN I LAUNCHES (AS OF SEPTEMBER 30, 1964)



NASA FORM 796 DEC. 62

[redacted]

Airframe 002

Airframe 002 is programmed to perform Apollo Mission A-004 at WSMR in September 1965. The first order objectives of the mission are to demonstrate structural integrity of the launch escape vehicle and to determine launch escape subsystem performance capabilities in a flight regime where significant aerodynamic loads will occur during launch escape vehicle tumbling. Present estimates place this at Mach No. 2.5 at 75 000 feet altitude (msl). Detailed trajectory work is underway to define the Little Joe II requirements.

AFRM 002 will be an airframe command and service module with launch escape subsystems, earth landing subsystems, and R&D instrumentation. AFRM 002 is in major structural assembly at Downey and follows AFRM 009 in the assembly line. It is scheduled to fly before AFRM 009 (Apollo Mission 201) because systems installation and checkout time is much shorter.

Boilerplate 15

The Apollo spacecraft mission A-102 was successfully accomplished on September 18, 1964. This was the second Saturn I/Apollo mission; the first was successfully launched on May 28, 1964. Boilerplate 15, the unmanned boilerplate spacecraft for Mission A-102, was launched at approximately 11:23 a.m. e.s.t. into earth orbit from complex 37B of the Eastern Test Range, Cape Kennedy, Florida, by the Saturn I Block II vehicle SA-7.

Test objectives were similar to those of Mission A-101 except that BP-15 demonstrated the alternate mode of tower jettison using the launch escape and pitch control motors. All objectives were fulfilled. The mission terminated when the spacecraft reentered on the 59th pass over the Indian Ocean.

During the launch countdown there were no holds caused by the spacecraft. All spacecraft subsystems fulfilled their specified functions throughout the countdown and planned flight test period. Engineering data were received through telemetry from all but two of the planned 133 measurements.

Evaluation is underway and test results will be published early in the next reporting period.

Boilerplates 16 and 26

Boilerplates 16 and 26 are uninstrumented boilerplate structures intended for launch aboard Saturns SA-9 and SA-8, respectively. The command modules for both vehicles were delivered to Cape Kennedy aboard the B-377 PG aircraft August 19, 1964. Launch escape towers were shipped by truck on August 13, 1964. Service modules and adapters for both vehicles had previously been delivered to MSFC to be modified for the Pegasus meteorite satellite.

Airframe 009

AFRM 009 continued through its manufacturing phase and as of this report is undergoing installation of secondary structure on the inner crew compartment. The heat shield is being prepared for a fit check with the crew compartment.

Planning activities at MSC were culminated with issuance of review copies of both the ASPO mission directive and the mission operations plan prepared by the Flight Operations Directorate. Final publication of these documents is scheduled for December and October, respectively.

RELIABILITY AND QUALITY ASSURANCE

Reliability and quality assurance program plans were prepared by MSC-ASPO. The status of the various reliability and quality activities and milestones included in these plans will be reported in this section in all future quarterly reports.

A NASA/NAA GFY65 Apollo program review was conducted in August and resulted in substantial realinement of the NAA Apollo Program. As a result of this review, NAA is preparing new reliability and quality assurance program plans.

NAA reliability engineering conducted 23 pre-award supplier surveys. A total of 200 surveys have been conducted to date. Also, NAA conducted reliability program audits of Leach Corporation, Marquardt, and Northrup-Ventura.

A survey of the reliability status of pyrotechnic devices for Apollo spacecraft was completed. The survey was made from information available at MSC, NAA/S&ID, and Space Ordnance Systems, Inc.

The MSC-ASPO reliability program plan was written and issued. A first draft of the Apollo spacecraft reliability requirements manual was written and is expected to be released in November 1964. This manual is a sister document to the ASPO reliability program plan and delineates the activities of all spacecraft program participants in the area of reliability.

Apollo quality assurance requirements have been prepared by the Apollo Spacecraft Program Office (ASPO) for various NASA-MSC operations. They were based on NASA NPC 200-2 and NPC 250-1 documents, as modified by ASPO, and tailored to the type and scope of activity at each location.

The lunar excursion module FMEA milestone schedule has been prepared. The FMEA's will be performed on all flight test articles and LEM vehicles one through ten. It should be noted that all LEM's will have essentially the same configurations as the LEM 10 vehicle, with the addition of a mission programmer in LEM's 1, 2, and 3 and other modifications required for their individual missions.

MSC-ASPO prepared and issued a formal set of qualification test ground rules.

Agreement was reached with MIT, GAEC, and NAA on the format for the qualification status list (QSL). The MSC format will be used with minor modification.

Investigations have been conducted to determine the criteria for stabilization/burn-in of spares items. Contractor statements on this subject indicate generally that spares burn-in will be the same as the basic hardware. Certain electronic tubes and semiconductors are recommended for burn-in. The requirements for burn-in interfaces and a requirement for preinstallation acceptance criteria (PIA) are under consideration.

Acceptance test ground rules have been prepared and are expected to be approved and distributed during the next quarter.

NAA/S&ID originated approximately 25 interservice data exchange program (IDEP) reports on the Apollo Program and forwarded them to the Air Force IDEP control center. Approximately 375 IDEP reports were requested and distributed by NAA/S&ID to Project Apollo engineers.

A preferred parts list for Apollo will be prepared from the qualification status lists (QSL) and the engineering master files submitted by Apollo spacecraft contractors. It is expected that MSC will begin generating a preferred parts list during the next quarter.

A total of 3663 nonconformance reports (NCR) were reviewed, evaluated, analyzed, processed, and transposed to transmittal sheets to be stored on magnetic tapes by NAA. NAA received 803 subcontractor and supplier problem reports and 991 scrap reports. The scrap reports involved 2954 parts. Parts with significant scrap rates were coldplates (158), initiators (328), electrical wire (15 350 feet), electrical boards (181), and AND gates (140).

Failure-data magnetic tapes are expected from GAEC and ACSP during the next quarter.

Failure-data tapes received at MSC are printed and distributed to the technical subsystem managers at MSC for their review and action. Summaries of the failure data are distributed to participating NASA-MSC officers.

GAEC expended a major effort in the area of weight-reliability and configuration trade-off studies. These studies have considered micrometeoroid shielding, the helium pressurization of the ascent and descent propulsion, electrical power system generation and distribution, and the overall G&N function.

Continued effort was expended by GAEC in reliability path analysis. The major results of the study will take the form of reliability paths and feasibility factors by mission phase for each nominal subsystem configuration. These results, together with operating times, stress factors, and updated equipment-failure rate estimates are being stored on computer tape as they are compiled. These tapes will be used in reliability estimation activities.

Based on a review of the BP-15 acceptance data package (ADP) conducted at NAA/S&ID and KSC during June, the ADP requirements document was revised in August. This revision was reviewed by the RASPO sites, and it was approved and issued to all contractors concerned. The revision did not change the intent of the original document but clarified the contractor submitted requirements in order to achieve a more useful field working document.

A detailed review of the NAA minimum airworthiness equipment lists for BP-15 revealed 30 problem areas. Of these 30 items, 18 were resolved by mutual agreement with NAA and MSC representatives and were closed out. The remaining 12 items require either additional information, correction of part numbers and references, or were not a part of the original list.

Agreement has been reached between AEDC, NASA, and the Apollo propulsion subsystem contractors on the quality systems to be used at AEDC during the Apollo test activities.

MSC has initiated an operational readiness program. The program is designed to assure success in meeting the launch window requirements. Mission essential GSE and SC equipments will be considered as an integrated whole in performing contingency analyses. The use of limited probability analyses, FMEA's, task time analyses, et cetera, will be used by organizational elements participating in the operational readiness program (reliability, logistics, human engineering, and GSE engineering).

The reliability goals for the meteoroid environment have been specifically excluded from consideration in the spacecraft mission success and crew safety reliability goals since the beginning of the program. The specifications have, however, required that the structural design of the spacecraft recognize the potential hazard of the meteoroid enviroment and permit the addition or reduction of meteoroid protection as our knowledge of the problem increases.

The probability goal for not aborting the mission because of meteoroid penetration was established at 0.99 for the spacecraft. The optimum distribution of this goal between the CSM and LEM for minimum weight was established at 0.995 for the CSM and 0.995 for the LEM. NAA was officially directed to use 0.995 for the mission-success reliability goal and to use the average sporadic meteoroid flux, defined in EC-1, in the design of meteoroid protection.

PROGRAM CONTROL

PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

CSM PERT

NAA has completed the realinement of the PERT reporting system to the revised program schedule. The additional Block I spacecraft have been added to the coverage. As of the end of September, there were 25 653 activities being displayed. Tape-to-tape transmission from NAA to MSC became operational during this time period. The number of changes to each update cycle in the networks have been as high at 10 000 because of the redefinition and alinement of program changes. They have now stabilized at about 4000 each cycle.

G&N PERT

During this period, a summarized schedule and performance reporting system was established and implemented denoting the systems status, allocation, schedule delivery date, expected delivery date, user need date, and trend. Integrated NASA-PERT was established for all Block I G&N Systems, and initial establishment of Block II and LEM G&N Systems integrated PERT was effected.

Future accomplishments include the implementation of contractor schedule and performance reporting system which is to be compatible with the G&N summarized reporting system referred to in the first paragraph. Further implementation of Block II and LEM G&N Systems PERT pending contract negotiations is planned.

LEM PERT

PERT effort during this period has been concentrated upon determining and incorporating interfaces between subsystems and GSE, vehicles and GSE, and associate contractor tasks, and the expansion of manufacturing, site activation, and training equipment networks and data. The total LEM PERT now covers about 29 500 activities.

CONFIGURATION MANAGEMENT

The preparation of instructions for the implementation of the Apollo configuration management manual, NPC 500-1, has progressed to final draft form. The implementation supplement is the result of a comprehensive review of the Apollo contractors existing specifications, drawings, and other engineering release systems, change accounting, and change identification systems. The results of this review and the maturity of the Apollo contracts managed by the Apollo Spacecraft Program Office indicated that detailed implementation of NPC 500-1 would be impossible without creating a major program impact. Therefore, the implementation instructions have been written to fully comply with the intent of NPC 500-1 with as little program perturbation as possible.

Procedures depicting documentation flow and the functions of the affected organizations within MSC are now in preparation. These procedures will be completed and configuration management will be contractually implemented with each Apollo contractor prior to November 1, 1964.

CSM FACILITIES

Two amendments to the Facilities Contract NAS 7-90(F) for NAA were approved this quarter. Amendment 2-5 provided an impact-test facility water poll extension of $27,600, and amendment 2-6 extended the completion time for installation of equipment cooling units in Building 290.

LEM FACILITIES

MSC approved a request from Pratt and Whitney Aircraft Division of United Aircraft, through GAEC, for approximately $49,000 worth of auxiliary vibration test equipment. The equipment is required to augment equipment used for the LEM fuel-cell assembly vibration testing.

In June 1964, MSC requested GAEC to make a thorough review of its facilities planning (as well as manpower and tooling) required to support LEM final assembly and checkout operations. GAEC presented the results of a 90-day reapprasial on September 17, 1964. The contractor's current planning consists of a 10 000-square-foot addition to Plant 5 which will contain increased clean room area within the building as well as additional assembly and test floor area.

GAEC was given approval to procure, as special test equipment (STE), a ground data-reduction station to support its LEM development programs. The station is to be located at Bethpage and is scheduled for completion August 1965. An interim capability is being planned to handle LEM requirements until the authorized station is operational.

SITE ACTIVATION

An integrated site activation status room at NAA/Downey has been made operational. The room contains schedules for facilities, GSE, facility modifications, installation, checkout, et cetera, for Downey, WSMR-PSDF, MSC/Houston, and ETR/MILA. A daily status of all activities and programming of activation tasks are developed by review and analysis of information in this room and other satellite rooms at each test site.

MSC has issued over-all activation schedules to NAA and GAEC for use in preparing detailed activation implementation plans for each test site.

The first house-spacecraft station at NAA/Downey has been partially activated, and the tests on BP-14 have started. The station is scheduled for completion during December 1964.

NAA test stand no. 1 at MSC/WSMR-PSDF has been activated and initial firings have been conducted. NAA test stand no. 2 is being activated to meet a February 1965 firing schedule.

NAA and GAEC are proceeding on schedule for activating the ETR/MILA facilities. A major effort is under way to have the required Apollo AFRM 009 support facilities available to support current test schedules.

Clear procedures for transmitting facility modifications or GSE installation requirements to KSC have been implemented for the industrial facilities at MILA. These procedures have made it possible for Apollo contractor requirements to reach KSC for implementation with a minimum of delay.

The construction of the MSC/WSMR-PSDF "common use" laboratory has been started and completion is scheduled for November 1964. This facility will house a ground data-reduction station and environmental test laboratories for use by NASA and their contractors. Complete operational capability of this facility is scheduled during late spring 1965. Interim laboratory facilities have been set up in the contractors preparation buildings at WSMR-PSDF until the laboratory is complete.

PUBLICATIONS

NORTH AMERICAN AVIATION, INC.
CONTRACT NAS 9-150

Report number	Subject	Report date
SID 62-90 Volumes 1, 2, &3	Apollo Flight Crew Performance Specification	July 15, 1964
SID 62-99-31	Monthly Weight and Balance Report for the Apollo Spacecraft	Sept. 1, 1964
SID 62-104	Structural Analysis of the 0.105 Scale Apollo Wind Tunnel Model (FS-2)	July 1964
SID 62-162	Apollo Training Plan	July 1, 1964
SID 62-300-27	Apollo Monthly Progress Report	Aug. 1, 1964
SID 62-417	Ground Support Equipment Planning and Requirements List; Vol. 1 - Listed by Model Designation Vol. 2 - Listed by Test Vehicle Vol. 3 - Listed by Test Site	Aug. 1, 1964
SID 62-784	Apollo Qualification Status List	July 1964
SID 62-823-4	Apollo Semiannual Materials Report	July 20, 1964
SID 62-1244	Apollo Lunar Excursion Module Performance and Interface Specification	Sept. 16, 1964
SID 63-21-21	Monthly Quality Status Report, Apollo SC	Sept. 10, 1964
SID 63-143-7	Actual Weight & Balance Report Boilerplate Stack No. 16, Vehicle for Micrometeoroid Exp.	Aug. 12, 1964
SID 63-223	Apollo Ground Support Equipment Operation and Service Instructions on Board Recorder Checkout Unit Model C14-031	July 30, 1964

[redacted]

Report number	Subject	Report date
SID 63-650 Volumes 1 & 2	Data Report for the Apollo Pressure Model (PS-3) With Strakes in Tunnels A & C of the AEDC Von Karman Gas Dynamics Facility	July 1964
SID 63-653	Apollo Ground Support Equipment Operation and Service Instructions Radar Transponder and Recovery Beacon Checkout Unit Model C14-112	Aug. 1, 1964
SID 63-705	Index of Apollo Support Manuals and Procedures Applicable to the following: BP6, 12, 13, 14, 15, 16, 23, 26; AFRM 001 and Test Fixture F-2	Aug. 15, 1964
SID 63-925	NASA Support Manual Apollo Ground Support Equipment Operation and Service Instructions, Launch Vehicle Substitute Unit (LJII) Model A14-018	July 20, 1964
SID 63-930	Apollo Ground Support Equipment Operation; and Service Instructions Pyrotechnics Initiators Substitute Set Model A14-003	Aug. 31, 1964
SID 63-1000	Apollo Manpower Application Report for the Month of July 1964	Aug. 1964
SID 63-1302	Apollo GSE Operation and Service Instructions Launch Vehicle Substitute Unit C-1, Model A14-021	Aug. 12, 1964
SID 63-1376	Structural Analysis of the 0.10 Scale Apollo Dynamics Stability Model (FD-6)	July 1964
SID 63-1416-2	Project Apollo Flight Test Report Boilerplate 12	July 1964
SID 63-1416-3	Project Apollo Flight Test Report Boilerplate 13	Aug. 1964
SID 64-174	Apollo Technical Manual System Dynamics Aerodynamic Data Manual	July 1, 1964

[redacted]

Report number	Subject	Report date
SID 64-181	Apollo Systems Engineering Manual Structural Dynamics	April 15, 1964
SID 64-435	Apollo Support Equipment Maintenance Propulsion System Checkout Unit Model C14-075	July 10, 1964
SID 64-437	Apollo Support Equipment Maintenance Pressure Calibration Unit Model C14-426	July 1, 1964
SID 64-690	Rendezvous Radar and Transponder Performance and Interface Specification	Sept. 30, 1964
SID 64-976	Apollo Study Summary Report	July 10, 1964
SID 64-1187-9	Bi-Weekly Apollo Test Site Activation Report	Sept. 15, 1964
SID 64-1268	Memo Report Command Module Lunar Excursion Module Tunnel Crew Transfer Test Phase II	Sept. 9, 1964
SID 64-1269	Apollo Crew Spacecraft Interface Zero Gravity Test Program	July 13, 1964
SID 64-1321	Apollo Ground Support Equipment Operation and Service Instructions Fuel Cell and Cryogenic Storage System Heater Power Supply Model A14-052	July 15, 1964
SID 64-1491	Engineering Test Requirements Airframe 008	Aug. 1, 1964
SID 64-1473	Apollo GSE Operation & Service Instructions Battery Conditioner Model S14-091	Aug. 14, 1964
SID 64-1574	GSE End Item Specification for Console Assy Freon Pressurization Unit Model C14-468	Aug. 20, 1964
SID 64T-54	Apollo Support Equipment Maintenance Water Glycol Cooling Unit Model S14-052	July 10, 1964

Report number	Subject	Report date
SID 64T-127	Apollo Support Equipment Maintenance Fuel Cell Power Plant Water Glycol Servicing Unit Model S14-054	Sept. 10, 1964
SID 64T-138	Apollo Support Equipment Maintenance Command Module Substitute Unit Model A14-051	Sept. 10, 1964

GRUMMAN AIRCRAFT CORPORATION
CONTRACT NAS 9-1100

Report number	Subject	Report date
LED-290-7	LEM Mission Programmer Preliminary Study Summary	Aug. 12, 1964
LED-360-9	LEM 1 Measurement List (Mission Category 1B5)	July 24, 1964
LED-490-12	LEM Mass Property Report	Sept. 1, 1964
LED-510-8	Thermal Analysis TM-2 Descent Stage Test	July 20, 1964
LLI-400-1, Rev. "F"	Ground Support Equipment Planning and Requirements List	Sept. 15, 1964
LLI-400-7, Rev. "A"	Special Test Equipment Planning and Requirements List	Aug. 19, 1964
LMA-790-1	LEM Familiarization Manual	July 15, 1964
LPC-905-44001	Test Procedure for Descent Stage Tank Skirt Proof Load	Aug. 10, 1964
LPL-81-1C	Quality Control Program Plan for Lunar Excursion Module - Volume I and II	Sept. 15, 1964
LPR-10-35	Monthly Progress Report No. 19	Sept. 10, 1964
LPR-50-15	Grumman Quality Status Report for LEM	Aug. 10, 1964
LPR-50-16	Grumman Quarterly Summary of Quality Control Program Performance Audits for LEM	Aug. 10, 1964

Report number	Subject	Report date
SPR-250-15	Study Summary Report	Sept. 10, 1964
LPR-550-6	Quarterly Reliability Status Report	Aug. 1, 1964
LPR-550-112	Monthly Failure Summary (LEM)	Sept. 15, 1964
LTP-340-4	LEM Crew Spacecraft Interface Reduced Gravity Test Plan	Aug. 8, 1964

MIT INSTRUMENTATION LABORATORY
CONTRACT NAS 9-153

Report number	Subject	Report date
E-1142, Rev. 24	System Status Report	Sept. 15, 1964
E-1540	A Preliminary Study of a Back-up Manual Navigation Scheme by Kennety Nordtvedt	Aug. 1964

HAMILTON STANDARD
CONTRACT NAS 9-1100

Report number	Subject	Report date
SVHSER 2807-4	LEM Environmental Control and Life Support Subsystem Quarterly Design	June 30, 1964
SVHSER 2790-11	LEM Environmental Control Subsystem Progress Report	June 1964
SVHSER 2790-12	LEM Environmental Control Subsystem Progress Report	July 1964
SVHS 2428	General Requirements - Space Suit System Hardware	Sept. 24, 1964
SVHS 2426	Back Pack - Design, Manufacturing and Test Requirements	Sept. 24, 1964

AiRESEARCH

Report number	Subject	Report date
SS-1013-4(27)	Monthly Progress Report, ECS, Project Apollo	Aug. 31, 1964

Report number	Subject	Report date
SS-1013-4(26)	Monthly Progress Report, ECS, Project Apollo	July 31, 1964
	NASA	
MSC-CSD-A017	Apollo Extravehicular Mobility Unit Design and Performance Specification	